BTeV WBS Dictionary

Subproject WBS Level 2 Element Number

WBS 1.5
Muon Detector

May 12, 2000

This document provides WBS Dictionary information
for a BTeV WBS Level 2 project and all its subprojects.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5

WBS Element Name:

Muon Detector

WBS Element Definition:

All components, labor and other costs associated with the development, design, construction, installation, and testing of the BTeV Muon Detector.

Ground Rules & Assumptions:

This section includes costs associated with the detector and front-end electronics. It does not include trigger or data acquisition electronics.

Estimate Source:

Basis of Estimate:

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1

WBS Element Name:

Proportional Tube Stations

WBS Element Definition:

All components, labor and other costs associated with the development, design, construction, and testing of the proportional tube stations.

Ground Rules & Assumptions:

Costing is based on sub-items that follow, broken into planks (the basic building block, consisting of 32 tubes in two layers offset by half a tube width) and quadrants, which is two octants together. Quadrants are the modules of which the final detector will be constructed in the C0 assembly hall. Electronics are not included in this section, nor is high voltage or gas distribution, or mechanical support of the quadrants.

Cost Estimate Source:

Cost is based on cost of sub-items given below.

Basis of Cost Estimate:

Cost is based on cost of sub-items given below.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.1

WBS Element Name:

Planks

WBS Element Definition:

Planks consist of 32 proportional tubes arranged in two layers of 16, offset by half a tube width ("picket fence"). Tubes will be made of seamless, thin wall stainless steel, 3/8" in diameter.

Ground Rules & Assumptions:

Cost Estimate Source:

Cost is based on cost of sub-items given below.

Basis of Cost Estimate:

Cost is based on cost of sub-items given below.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.1.1

WBS Element Name:

Development and Prototype Planks

WBS Element Definition:

Planks will be built for prototyping and beam test studies.

Ground Rules & Assumptions:

We assume we will build 20 planks for prototyping and for beam tests. We will also build a complete quadrant of planks as a prototype, and plan to do a beam test with it as well. University of Illinois, University of Puerto Rico, and Vanderbilt University are responsible.

Cost Estimate Source:

Costing is based on cost for production run in next section. Dictionary elements for the components are given in that section rather than here. Basis for cost is the same, except that fabrication cost is adjusted to account for the smaller number of items being made (which means cost will be higher in most cases).

Basis of Cost Estimate:

Cost is based on cost of sub-items given below.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.1.2

WBS Element Name:

Plank Production

WBS Element Definition:

Proportional tube “planks” form the basic building block of the system.

Ground Rules & Assumptions:

We will build a total of 2912 planks in the production run. 2496 are needed for both arms of the detector, the rest are spares. It is difficult to access these planks once installed, and it will likely be a 2-3 day job to replace one or many. We therefore have built it redundancy by using 4 views in each station and are building many spare planks so that we can replace bad planks in a hurry and repair them offiline.

Cost Estimate Source:

Cost is based on cost of sub-items given below.

Basis of Cost Estimate:

Cost is based on cost of sub-items given below.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.1.2.1

WBS Element Name:

Stainless Tubes

WBS Element Definition:

Seamless stainless steel tubes, 3/8 inch outer diameter, 0.010 inch wall thickness, various lengths. Used to construct proportional tubes. Tubes will be purchased in stock lengths, cut to appropriate length, deburred.

Ground Rules & Assumptions:

Project requires 340,000 feet of tube. 93,000 tubes in 26 different lengths (from 1 foot to 6 foot) will be cut. An equal number of tubes of each length will but cut. University of Illinois, University of Puerto Rico, and Vanderbilt University are responsible for purchase and production of tubes.

Cost Estimate Source:

Tube cost is based on vendor information for applicable quantities.
Cutting and deburring cost is machinist estimate in Vanderbilt University Machine Shop from small production run made for test beam studies in summer of 1999.

Basis of Cost Estimate:

Costing estimates are from:

(1) Vendor estimate from Superior Tube Company.
(2) Machinist estimate: based on production run of 350 tubes made for beam test detector.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.1.2.2

WBS Element Name:

Support Ribs

WBS Element Definition:

Support Ribs provide support in the middle of long proportional tube planks. 32 holes are drilled in each (two rows of 16, offset by half a tube diameter). The spacing between tubes in each row is extremely small, and the rib is shaped so that the tube spacing is maintained between adjacent planks. Ribs are made of brass and will be soldered in place. Threaded holes will be machined on one side so that all the planks in each view can be attached to their aluminum support plate.

Ground Rules & Assumptions:

5824 ribs will be made, including spares.
Illinois, Puerto Rico, and Vanderbilt will share responsibility for production.

Estimate Source:

Brass cost is based on vendor information for applicable quantities. Machining cost is machinist estimate, based on experience in a small production run in the Vanderbilt shop for the 1999 beam test. Cost assumes Vanderbilt shop rate of $30/hour, which is very competitive.

Basis of Estimate:

Machining cost estimate is from Vanderbilt University Science Machine Shop, and includes cost of fabrication in a CNC mill.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.1.2.3

WBS Element Name:

Gas Manifolds

WBS Element Definition:

Gas manifolds for the proportional tube planks. Manifolds are made of brass and will be soldered in place. Threaded holes will be machined on one side so that all the planks in each view can be attached to their aluminum support plate.

Ground Rules & Assumptions:

5824 ribs will be made, including spares.
Illinois, Puerto Rico, and Vanderbilt will share responsibility for production.

Estimate Source:

Brass cost is based on vendor information for applicable quantities. Machining cost is machinist estimate, based on experience in a small production run in the Vanderbilt shop for the 1999 beam test. Cost assumes Vanderbilt shop rate of $30/hour, which is very competitive.

Basis of Estimate:

Machining cost estimate is from Vanderbilt University Science Machine Shop, assuming fabrication in a CNC mill.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.1.2.4

WBS Element Name:

Crimp Pins

WBS Element Definition:

Crimp Pins are used to center the wire in the center of the proportional tubes and to hold the wire in place via a crimp. The pin is a brass tube, 1/16 inch in diameter with 0.030 inch thick walls, and 1 inch in length. At one end of the tube a "v" shaped indentation is rolled around a circumference, this forms a double funnel that centers the wire. The funnel shape eases threading of the sense wire. The brass tubes will be cut from stock brass tube, deburred, and rolled on a die to form the double funnel.

Ground Rules & Assumptions:

280,000 end plugs will be made, including those needed to fabricate spare planks. 50% extra will be made because there is substantial waste in stringing process (crimp doesn't always take, if it doesn't, crimp pin must be thrown out) and for restringing during the run. Illinois, Puerto Rico, and Vanderbilt are responsible for this item.

Estimate Source:

Brass tubing cost is based on vendor information for applicable quantities. Machining cost is machinist estimate.

Basis of Estimate:

Machining cost estimate is from Vanderbilt University Science Machine Shop, and includes cost of rolling die fabrication and cutting and rolling of all 240,000 pins.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.1.2.5

WBS Element Name:

End Plugs

WBS Element Definition:

End Plugs are inserted into the ends of the stainless tubes. They center the crimp pin and hold it in place. There are three holes spaced equally around the crimp pin, these are for gas flow. Plugs are made of delrin plastic.

Ground Rules & Assumptions:

280,000 end plugs will be made, including those needed to fabricate spare planks. 50% extra will be made because there is substantial waste in stringing process (crimp doesn't always take, if it doesn't, crimp pin must be thrown out) and for restringing during the run. Fabrication cost includes insertion of crimp pins. Illinois, Puerto Rico, and Vanderbilt are responsible for this item.

Estimate Source:

Delrin cost is based on vendor information for applicable quantities. Machining cost is machinist estimate.

Basis of Estimate:

Machining cost estimate is from Vanderbilt University Machine Shop, based on small production run for 1999 beam test.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.1.2.6

WBS Element Name:

Gas Connectors

WBS Element Definition:

Stainless steel tubes, two per manifold to insure sufficient flow.

Ground Rules & Assumptions:

11648 tubes will be made. Tubes on front-end electronics end are 5 inches long and pass through EMI shield. Tubes on opposite end are 1 inch long. Tubes are soldered to manifolds. Tubes will be cut and deburred.

Estimate Source:

Stainless steel cost is based on vendor information for applicable quantities. Machining cost is machinist estimate.

Basis of Estimate:

Machining cost estimate is from Vanderbilt University Machine Shop, based on previous experience.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.1.2.7

WBS Element Name:

Plank pre-assembly

WBS Element Definition:

Planks are pre-assembled before stringing. 32 tubes, support ribs, and gas manifolds are soldered together.

Ground Rules & Assumptions:

2912 planks will be soldered. Soldering will be done in University machine shops or equivalent.

Estimate Source:

Cost estimate is from Vanderbilt University Machine Shop, and assumes half an hour per plank.

Basis of Estimate:

Machining cost estimate is from Vanderbilt University Machine Shop, and is based on previous experience with similar tasks.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.1.2.8

WBS Element Name:

Stringing

WBS Element Definition:

Pre-assembled planks will be strung using mostly student labor with technician help and physicist supervision.

Ground Rules & Assumptions:

2912 planks will be strung, which includes spares to be swapped in during the run if needed. Based on experience stringing several planks for the 1999 beam test, we estimate it will take 2 people 2.5 hours to string a plank. This includes continuity testing and restringing. Planks will be strung at Illinois, Puerto Rico, and Vanderbilt.

Estimate Source:

Cost of this item is all labor, and is based on experience stringing several planks for the 1999 beam test.

Basis of Estimate:

Cost of this item is all labor, and is based on experience stringing several planks for the 1999 beam test.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.1.2.9

WBS Element Name:

Plank Testing

WBS Element Definition:

Plank tension and efficiency will be tested after stringing. This item includes the labor involved. Subsequent items will describe cost of equipment and apparatus involved.

Ground Rules & Assumptions:

2912 planks will be tested. Testing will be done in university labs by undergraduates, technicians, and physicists. Testing will be done at Illinois, Puerto Rico, and Vanderbilt immediately after stringing so that bad planks can be re-strung. Most of the labor involved in tension measurement is setup, actual testing will be automated. The same is true for efficiency measurements. All the planks strung each day will be tested in a cosmic ray telescope for 20 hours or so.

Estimate Source:

Cost estimate is based on experience with planks used in 1999 beam test.

Basis of Estimate:

Cost estimate is based on experience with planks used in 1999 beam test.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.1.2.10

WBS Element Name:

Plank tension test stand

WBS Element Definition:

Planks tension is measured using a dipole magnetic field and an AC current on the wire. The resonant AC frequency gives the tension.

Ground Rules & Assumptions:

Test equipment consists of a PC and a PCI bus interface to a wave generator and an AC/DC converter. Labview will be used to control the test and record the results. Equipment will be assembled and software written at Vanderbilt.

Estimate Source:

Cost estimate is based on prototype work being done at Vanderbilt.

Basis of Estimate:

Estimate is based on experience gained via prototype work at Vanderbilt.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.1.2.11

WBS Element Name:

Plank efficiency test stand

WBS Element Definition:

Efficiency of the proportional tubes in each plank will be roughly determined in a cosmic ray test stand. Data from 20 hours exposure will be taken on each tube.

Ground Rules & Assumptions:

Test stand will consist of a scintillator paddle cosmic ray telescope that will provide the trigger. A PC or workstation with a CAMAC interface will be used to readout scintillators and proportional tubes. High voltage for the proportional tubes and for the phototubes is included. Illinois, Puerto Rico, and Vanderbilt will each build a test stand for testing the planks that they string. Problem planks will be re-strung.

Estimate Source:

Cost estimate based on previous experience with other cosmic ray test stands and similar tests.

Basis of Estimate:

Cost estimate based on previous experience with other cosmic ray test stands and similar tests.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.2

WBS Element Name:

Quadrants

WBS Element Definition:

A quadrant is the module from which the muon detector stations will be built in the C0 hall.

Ground Rules & Assumptions:

A quadrant consists of two octants. Each octant contains 4 layers of proportional tube planks (each layer consists of 13 planks, side by side. Each octant is supported by a square sheet of aluminum. Half of this square will be covered by planks, the other half will be used for electronics, cabling, etc. for that view. So that adjacent octants can overlap, the quadrant consists of 8 total layers – four for each octant.

Estimate Source:

Cost estimate is based on the price of sub-items below, which include fabricated parts, assembly, and testing.

Basis of Estimate:

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.2.1

WBS Element Name:

Quadrant Development and Prototypes

WBS Element Definition:

One quadrant will be built for prototyping and development. It will be tested in a test beam.

Ground Rules & Assumptions:

The prototype quadrant will be built to test and develop construction methods and techniques, cabling, and electronics attachment and readout. It will be tested in a test beam.

Estimate Source:

Cost estimate based on subitems under Quadrant Production (1.5.1.2.2.1-1.5.1.2.2.4), which will be similar.
Separate dictionary items were not made for these subitems since their description is essentially the same.

Basis of Estimate:

Cost estimate is taken from subitems under Quadrant Production, but are somewhat higher since there will be fewer or each item made.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.2.2

WBS Element Name:

Quadrant Production

WBS Element Definition:

One quadrant will be built for prototyping and development. It will be tested in a test beam.

Ground Rules & Assumptions:

The prototype quadrant will be built to test and develop construction methods and techniques, cabling, and electronics attachment and readout. It will be tested in a test beam.

Estimate Source:

Cost estimate based on subitems under Quadrant Production, which will be similar. Separate dictionary items were not made for these subitems since their description is essentially the same.

Basis of Estimate:

Cost estimate is taken from subitems under Quadrant Production, but are somewhat higher since there will be fewer or each item made.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.2.2.1

WBS Element Name:

Aluminum Sheets

WBS Element Definition:

Each layer of 13 planks will be held in place by a layer consisting of two 4' by 8' aluminum sheets, 0.125" thick. Holes will be pre-drilled (6 patterns are required) and then countersunk. Fasteners will pass though these holes and be screwed into pre-drilled and pre-threaded holes in support ribs and gas manifolds. Some machining of each sheet will be necessary: the edges will be beveled to make it easier to fit quadrants together when building each detector station.

Ground Rules & Assumptions:

Illinois, Puerto Rico, and Vanderbilt are responsible for this item.

Estimate Source:

Material estimate is from a vendor quote. Fabrication estimate is from Vanderbilt Machine Shop.

Basis of Estimate:

Material estimate is from a vendor quote. Fabrication estimate is from Vanderbilt Machine Shop.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.2.2.2

WBS Element Name:

Miscellaneous Parts

WBS Element Definition:

Spacers, aluminum side supports, and fasteners.

Ground Rules & Assumptions:

We assume 12 fasteners (screws) per plank, and 6 spacers per layer of planks, and two supports per quad. Illinois, Puerto Rico, and Vanderbilt are responsible for this item.

Estimate Source:

Cost estimate is from Vanderbilt machine shop.

Basis of Estimate:

Cost estimate is from Vanderbilt machine shop

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.2.2.3

WBS Element Name:

Aluminum sandwich plates

WBS Element Definition:

These plates will hold quadrants together in final assembly.

Ground Rules & Assumptions:

Sandwich plates are 0.125" Aluminum sheets, 2' x 4'. One goes on each side of quadrant and connects two quadrants to hold them together in final assembly. There is a net of one plate per quad. Illinois, Puerto Rico, and Vanderbilt are responsible for this item.

Estimate Source:

Material estimate is from a vendor quote. Fabrication estimate is from Vanderbilt Machine Shop.

Basis of Estimate:

Material estimate is from a vendor quote. Fabrication estimate is from Vanderbilt Machine Shop.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.2.2.4

WBS Element Name:

Quadrant Assembly and Testing

WBS Element Definition:

Assembly of planks into quads, including all front electronics, HV and gas connections, and cabling to edge of quadrant.

Ground Rules & Assumptions:

Thirteen planks form one layer, and there will be a total of 8 layers of planks in a quad. Quads will be assembled a layer at a time. Illinois, Puerto Rico, and Vanderbilt are responsible for this item.

Estimate Source:

Estimate is from Vanderbilt Machine Shop.

Basis of Estimate:

Estimate is from Vanderbilt Machine Shop.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.1.2.2.5

WBS Element Name:

Quadrant Assembly Equipment

WBS Element Definition:

Special tables will be built with large access holes. Also a lifting jig for each layer and for final quad when assembled.

Ground Rules & Assumptions:

Planks in a layer are placed on top of aluminum sheet for that layer. Planks are then fastened to the sheet using fasteners screwed in from below. This will take place on special table built for this purpose. Lifting jig will be simple spreader bar assembly for lifting layers and quads. Illinois, Puerto Rico, and Vanderbilt are responsible for this item.

Estimate Source:

Estimate is from Vanderbilt Machine Shop.

Basis of Estimate:

Estimate is from Vanderbilt Machine Shop.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2

WBS Element Name:

Front-End Electronics

WBS Element Definition:

These are the conglomeration of circuit boards and IC's that conspire to amplify and digitize the fast rising (8 ns) part of the signal coming from the muon proportional tubes. As well, we include a section on the essential faraday shielding enclosure for the front end electronics and a section on auxiliary parts we plan to use in an active filter for the input stage.

Ground Rules & Assumptions:

Each unit that we make will be based on a 32 channel footprint. Each channel has the potential to be 99 percent efficient for a particle passing through a proportional tube. We will need a total of 79872 channels in the detector, not counting spares. Our spares for the front end board will be 10% of the production with a 5% added to cover the cost of producing an entire quadrant which we can presumably use as a spare later. For this reason, much of our procurement for production could occur as soon as FY 2002. Spares for interface parts are higher as explained below.

Estimate Source:

We will largely be basing our costs on the prototype muon electronics that we used in a beam test in the summer of 1999 and the cost to produce the front end cards for the CDF COT detector. Some of our costing is based therefore on a small (0.1 percent) production run. We will add in costs for items that have changed or that we feel are needed based on the test beam results. These costs will come from commercial sources and/or past experience.

Basis of Estimate:

Two separate components, or boards, will be costed. An interface board that connects the prop tubes to the amplifier/discriminator board, and the amplifier/discriminator board. We feel that this is a rough estimate and should be supplemented by a prototyping cycle for the electronics we intend to make. One support element will also be costed: the enclosure for the electronics.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.1

WBS Element Name:

ASDQ IC's

WBS Element Definition:

These are 8 channel ASIC's that amplify and digitized the first 8ns or so of the analog signal coming from the proportional tubes. This is a fairly stable chip and is used extensively in the CDF Central Outer Tracker (COT). We have done our initial prototyping using the ASD8B which is a similar, older ASIC that is now obsolete. Our estimates and basis for confidence in the chip come from University of Pennsylvania and our experience with the ASD8B.

Ground Rules & Assumptions:

We will need 4 chips for each front end board. There will be 2496 boards total and 250 spares. With some chips to use for prototyping.

Cost Estimate Source:

The cost will be based on our actual cost for chips used in the summer test beam. There will be an adjustment for the added expense of ASDQ's over ASD8B's.

Basis of Cost Estimate:

Actual expense and cost estimates from University of Pennsylvania. Time estimates are based on our experience during the summer running.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.1.1

WBS Element Name:

Development and Prototypes

WBS Element Definition:

From the tests we performed in the summer of 1999, it was obvious that we needed another prototyping cycle. We are planning on making a total of 20 new prototype cards and there are 4 chips per card. The ASDQ IC has already gone through prototype and fabrication phase. Hence, there is no need for another prototype of this chip. All our prototyping needs will be for the application of the chip.

Ground Rules & Assumptions:

We will budget for enough electronics to outfit 20 planks of 32 channels each. This comes to 80 chips. We already have a few in hand, so our contingency in zero.

Estimate Source:

Last summer's prototyping run expense, e-mail quote from University of Pennsylvania.

Basis of Estimate:

Cost of last summer's electronics and projected cost from the quote.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.1.2

WBS Element Name:

Production

WBS Element Definition:

University of Pennsylvania is nice enough to give us a break on the prototyping cost. The pricing therefore for production is the same as for prototyping for each chip.

Ground Rules & Assumptions:

We will budget for enough electronics to outfit 2496 planks of 32 channels each. This comes to 9984 chips, fully tested. We include 15 percent spares.

Estimate Source:

Last summer's prototyping run expense, e-mail quote from University of Pennsylvania.

Basis of Estimate:

Cost of last summer's electronics and projected cost from the quote.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.2

WBS Element Name:

Control/Monitoring & Timing (C/M&T) and Data Readout Electronics

WBS Element Definition:

This element describes the Control/Monitoring & Timing and Data Readout Electronics for the Muon data combiner board. This includes the TMC^2 FPGA, auxiliary electronics (level translators, PROMs, etc.) and optoelectronics used for the serial data link. The electronics will be able to support 416 channel data combiner boards with an average occupancy of 2.0%. The serial optical data link will be capable of supporting a pre-encoded data rate of 2080Mbps (16 bits at 130Mhz).

Ground Rules & Assumptions:

Assume 416 channel data combiner boards (combines 13 planks at 32 channels per plank). Data is over threshold with an average occupancy of 2.0%. Data link supports 2080Mbps (16 bit words at 130Mhz).

Estimate Source:

Fermilab, Electronic Systems Engineering Department personnel.
Vendor quotes from Xilinx sales representative.
Vendor quotes.

Basis of Estimate:

Time estimates are based on historical experiences with projects of similar complexity.
Present day state of the art technology components costs based on anticipated pricing for FY2004. Historical pricing data trends of components of relative same complexity used to extrapolate pricing into FY2004.
Low end technology components are based on present day pricing for both production and prototypes.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.2.1

WBS Element Name:

BTeV-Standard Control/Monitoring & Timing and Data Readout (TMC2) FPGA

WBS Element Definition:

This element describes the Control/Monitoring & Timing and Data Readout FPGA (TMC^2 FPGA) for Muon unique prototyping as well as production costs of the complete (Muon unique and BTeV common) TMC^2 FPGA. The TMC^2 FPGA contains both the data combining function and the timing control and monitoring (TC/M) function. The data combining function receives digitized data from multiple detector channels, formats it, and sends the data to a serializer for transmission. The TC/M receives incoming serial control commands, recovers the 53 MHz clock, decodes the control commands, and returns serialized monitoring information to monitoring link. The readout clock will be generated from a 130 MHz on board crystal allowing a readout rate of 16 bits at 130 MHz = 2080 Mbps.

Ground Rules & Assumptions:

Assume 416 channel data combiner boards. Data is over threshold with an average occupancy of 2.0%. Data link supports 2080 Mbps (16 bit words at 130 MHz).

Estimate Source:

Fermilab, Electronic Systems Engineering Department personnel.
Vendor quotes from Xilinx sales representative.

Basis of Estimate:

Time estimates are based on historical experiences with projects of similar complexity.
Component costs based on anticipated pricing for production quantities of Xilinx Spartan II Series XC2S150 in a FG456 package in FY2004. Historical pricing data trends of components of relative same complexity used to extrapolate pricing into FY2004.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.2.1.1

WBS Element Name:

Development and Prototypes

WBS Element Definition:

This element describes the development and prototyping of the Muon unique firmware in the TMC^2 FPGA. Developing and prototyping the Muon unique firmware in the TMC^2 FPGA involves: design and simulations of the FPGA firmware, design reviews, and prototype construction and debugging.

Ground Rules & Assumptions:

Assume 416 channel data combiner boards. Data is over threshold with an average occupancy of 2.0%. Data link supports 2080Mbps (16 bit words at 130Mhz). Reviews will take place either on-site at Fermilab, or via tele/video conference. Prototype testing is complete when the Muon unique firmware of the TMC^2 FPGA has the functionality and performance that is required of the production TMC^2 FPGA.

Estimate Source:

Fermilab, Electronic Systems Engineering Department personnel.

Basis of Estimate:

Time estimates are based on historical experiences with projects of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.2.1.1.1

WBS Element Name:

Firmware Specific to the Muon Detector

WBS Element Definition:

This element describes the firmware design and development that is uniquely required for the Muon TMC^2 FPGA. Muon unique firmware is needed to handle 416 serialized input channels of over threshold data. This does not include the common firmware that is covered in section 1.10.

Ground Rules & Assumptions:

The Muon unique TMC^2 FPGA firmware will be developed and simulated in VHDL. Data out of the TMC^2 to the data link serializer will be 16 bit parallel at a rate of 2080 Mbps (16 bits at 130 MHz).
There will be 416 channels of serialized over threshold data into the Muon TMC^2 FPGA. Groups of 12 channels will be serialized via auxiliary electronics for a total of 35 serial lines into the TMC^2 FPGA.

Estimate Source:

Fermilab, Electronic Systems Engineering Department personnel.

Basis of Estimate:

Time estimates are based on historical experiences with projects of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.2.1.1.2

WBS Element Name:

Design and Simulations Reviews

WBS Element Definition:

This element describes the time required for design reviews needed to insure the Muon unique firmware in the TMC^2 FPGA is designed with the proper performance and functionality needed by its users before the first pass prototype is constructed.

Ground Rules & Assumptions:

Assume reviews will take place either on-site at Fermilab, or via tele/video conference.

Estimate Source:

Fermilab, Electronic Systems Engineering Department personnel.

Basis of Estimate:

Time estimates are based on historical experiences with projects of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.2.1.1.3

WBS Element Name:

Prototype Testing

WBS Element Definition:

This element describes the prototype testing of the Muon unique firmware in the TMC^2 FPGA. This includes the time required to debug all of the Muon unique TMC^2 FPGA originally designed functionality and any additional time required to add and debug functionality enhancements/changes to the first pass design.

Ground Rules & Assumptions:

Assume prototype testing is complete when the Muon unique firmware of the TMC^2 FPGA has the functionality and performance that is required of the production TMC^2 FPGA.

Estimate Source:

Fermilab, Electronic Systems Engineering Department personnel.

Basis of Estimate:

Time estimates are based on historical experiences with projects of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.2.1.1.4

WBS Element Name:

Prototype Muon TMC2 FPGAs

WBS Element Definition:

This element describes the component costs of the Muon TMC^2 FPGAs used in prototype data combiner boards.

Ground Rules & Assumptions:

Assume the prototype Muon data combiner board will be 416 channels of overthreshold data into the TMC^2 FPGA. Data out of the TMC^2 to the data link serializer will be 16 bit parallel at a rate of 2080Mbps (16 bits at 130Mhz). The TMC^2 FPGAs will have the size and performance to meet specifications.

Estimate Source:

Fermilab, Electronic Systems Engineering Department personnel.
Vendor quotes from Xilinx sales representative.

Basis of Estimate:

Component costs based on present day pricing for prototype quantities of Xilinx Spartan II Series XC2S150 in a FG456 package.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.2.1.2

WBS Element Name:

Production

WBS Element Definition:

This element describes the production Muon TMC^2 FPGA. This includes production reviews, component costs, and production testing. The TMC^2 FPGA function includes: timing (clock recovery and distribution), monitoring, control command decoding, and combining (combining multiple detector input channels to send to a single high speed data link).

Ground Rules & Assumptions:

Assume 416 channel data combiner boards. Data is over threshold with an average occupancy of 2.0%. Groups of 12 channels will be serialized via auxiliary electronics for a total of 35 serial lines into the TMC^2 FPGA.
Data link supports 2080 Mbps (16 bit words at 130 MHz).
Reviews will take place either on-site at Fermilab, or via tele/video conference.
Production components will be purchased in FY2004.

Estimate Source:

Fermilab, Electronic Systems Engineering Department personnel.
Vendor quotes from Xilinx sales representative.

Basis of Estimate:

Time estimates are based on historical experiences with projects of similar complexity.
Component costs based on anticipated pricing for production quantities of Xilinx Spartan II Series XC2S150 in a FG456 package in FY2004. Historical pricing data trends of components of relative same complexity used to extrapolate pricing into FY2004.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.2.1.2.1

WBS Element Name:

Production Reviews

WBS Element Definition:

This element describes the production design reviews required before production quantities of the Control/Monitoring & Timing and Data Readout Data Combiner (TMC^2) FPGA are ordered. The purpose of these reviews is to establish an agreement that the production Data Combiner FPGA will meet the performance requirements of its users.

Ground Rules & Assumptions:

Assume reviews will take place either on-site at Fermilab, or via tele/video conference.

Estimate Source:

Fermilab, Electronic Systems Engineering Department personnel.

Basis of Estimate:

Time estimates are based on historical experiences with projects of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.2.1.2.2

WBS Element Name:

Production Muon TMC^2 FPGAs

WBS Element Definition:

This element describes the component costs of the TMC^2 FPGAs that will be used in the production Muon data combiner boards. The TMC^2 FPGA function includes: timing (clock recovery and distribution), monitoring, control command decoding, and combining (muxing multiple detector input channels to send to a single high speed data link). The TMC^2 will receive 35 serial lines. Each input serial line is the output of a serial shift register containing 12 channels of data each. The TMC^2 will provided the serial shift registers a 106 MHz readout clock.

Ground Rules & Assumptions:

Assume the production Muon data combiner board will be 416 channels of overthreshold data in to the TMC^2 FPGAs. Data out of the TMC^2 to the data link serializer will be 16 bit parallel at a rate of 2080 Mbps (16 bits at 130 MHz). The TMC^2 FPGAs will have the size and performance to meet specifications. Production components will be purchased in FY2004.

Estimate Source:

Vendor quote from Xilinx sales representative.

Basis of Estimate:

Costs based on anticipated pricing for production quantities of Xilinx Spartan II Series XC2S150 in a FG456 package in FY2004. Historical pricing data trends of components of relative same complexity used to extrapolate pricing into FY2004.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.2.1.2.3

WBS Element Name:

Production Testing

WBS Element Definition:

This element describes the production testing of the TMC^2 FPGA. The purpose of production testing is to verify the TMC^2 functionality on all of the Muon production data combiner boards before they are installed in the final system. The TMC^2 FPGA function includes: timing (clock recovery and distribution), monitoring, control command decoding, and combining (muxing multiple detector input channels to send to a single high speed data link)

Ground Rules & Assumptions:

Assume testing is an automated test that verifies the functionality of the Muon TMC^2 FPGA.

Estimate Source:

Fermilab, Electronic Systems Engineering Department personnel.

Basis of Estimate:

Time estimates are based on historical experiences with projects of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.3

WBS Element Name:

Data Serializer/Transmitter and C/M&T and Data Opto-Electronics

WBS Element Definition:

This element includes prototyping and production costs of the 2.5 Gbps data serializer and encoder, VCSEL for transmitting 2.5 Gbps detector data, another VCSEL for transmitting slow speed monitoring data, PIN photodiode for receiving slow speed optical control data, and fiber optic connectors.
Development and prototyping costs include any development and prototyping related to any Muon specific constraints (not the BTeV common development and prototyping costs).

Ground Rules & Assumptions:

The Muon opto-electronic components will be the same as those used for the Pixel detector.
The TMC^2 FPGA will serialize and deserialize the monitor and control data, respectively.

Estimate Source:

Vendor estimates for optical devices and packaging. Engineering judgment will be applied to costing prototypes, testing and reviews.

Basis of Estimate:

Quotation of Optical parts and packaging.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.3.1

WBS Element Name:

Development and Prototypes

WBS Element Definition:

This element describes the development and prototypes of the data serializer/encoder, PIN-Diode and VCSEL and substrate used on the Muon data combiner board for control/monitoring & timing and data readout.

Ground Rules & Assumptions:

Prototypes will be developed at the Electronic Systems Engineering Department of Fermilab.

Estimate Source:

Engineering judgement.

Basis of Estimate:

Time estimates are based on historical experiences with projects of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.3.1.1

WBS Element Name:

Prototype Data Serializer/Transmitter ICs

WBS Element Definition:

This element describes the development and prototypes of the data serializer/encoder used on the Muon data combiner board for control/monitoring & timing and data readout. Development and prototyping costs include any development and prototyping related to any Muon specific constraints (not the BTeV common development and prototyping costs).

Ground Rules & Assumptions:

Prototypes will be developed at the Electronic Systems Engineering Department of Fermilab.

Estimate Source:

Engineering judgement.

Basis of Estimate:

Time estimates are based on historical experiences with projects of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.3.1.2

WBS Element Name:

Design Reviews and Prototype Testing

WBS Element Definition:

This element describes the design reviews and prototype testing associated with the development and prototypes of the data serializer/encoder, Pin-Diode and VCSEL and substrate used on the Muon data combiner board for control/monitoring & timing and data readout.

Ground Rules & Assumptions:

Prototypes will be developed at the Electronic Systems Engineering Department of Fermilab.

Estimate Source:

Engineering judgement.

Basis of Estimate:

Time estimates are based on historical experiences with projects of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.3.2

WBS Element Name:

Production

WBS Element Definition:

This element describes the production costs of the Muon control/monitoring & timing and data readout opto-electronics. This includes production reviews, component costs, and production testing.

Ground Rules & Assumptions:

Muon detector will use 416 channel data combiner boards. Muon system will have 69120 channels total. The same VCSEL laser and fiber optic connector will be used for both the data link and the monitor link. Each boards will require 2 VCSELs, 3 fiber optic connectors, and 1 PIN photodiode.

Estimate Source:

Vendor estimates. Engineering judgement

Basis of Estimate:

Production costs based on suppliers' quotations and estimates based on similar work or engineering judgement.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.3.2.1

WBS Element Name:

Testing: Automated and Field

WBS Element Definition:

This element describes the production and field testing of the control/monitoring & timing and data readout optoelectronics. Production testing will be used to verify performance of the optoelectronic components before they are installed in the final system. Field testing will be done to verify performance of the optoelectronic components after installation into the final system.

Ground Rules & Assumptions:

Tests will be carried out by the optoelectronic users.

Estimate Source:

Fermilab, Electronic Systems Engineering Department, Fermilab VLSI group and Optoelectronic users.

Basis of Estimate:

Time estimates are based on historical experiences with projects of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.3.2.2

WBS Element Name:

Production C/M&T and Data Readout Opto-Electronics

WBS Element Definition:

This element contains the component costs of the production control/monitoring & timing and data readout opto-electronics. Each boards will require 2 VCSELS, 3 fiber optic connectors, and 1 PIN photodiode.

Ground Rules & Assumptions:

Muon detector will use 416 channel boards. Muon system will have 69120 channels total. The same VCSEL laser and fiber optic connector will be used for both the data link and the monitor link. Each boards will require 2 VCSELS, 3 fiber optic connectors, and 1 PIN photodiode.

Estimate Source:

Vendor estimates. Engineering judgement

Basis of Estimate:

Production costs based on suppliers' quotations and estimates based on similar work or engineering judgement.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.3.2.3

WBS Element Name:

Production Data Serializer/Transmitter ICs

WBS Element Definition:

This element contains the component costs of the production data serializer/encoder. The data serializer/encoder receives 16 bit parallel data at 130 MHz from the TMC^2, encodes and serializes the data using a DC balanced algorithm, and drives the serial data to a VCSEL for optical transmission to the L1 Buffers.

Ground Rules & Assumptions:

Muon detector will use 416 channel boards. Muon system will have 69120 channels total. The same VCSEL laser and fiber optic connector will be used for both the data link and the monitor link. Each boards will require 2 VCSELS, 3 fiber optic connectors, and 1 PIN photodiode.

Estimate Source:

Vendor estimates. Engineering judgement

Basis of Estimate:

Production costs based on suppliers' quotations and estimates based on similar work or engineering judgement.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4

WBS Element Name:

Auxiliary Front End Board Electronic Components

WBS Element Definition:

These are a combination of DAC's, ADC's and all the transistors, diodes, resistors and capacitors that we expect to use in addition to the passive components on the COT card that we think we need to read out the prop tubes. We are adding an additional cost to do a filter in the first stage. The filter is based on the successful front-end design of the front end boards used for the straw electronics in E687. This conditioning section will consist of no more than a protection diode and 2 transistors with some resistors and capacitors. We think this addition to be fairly important given the ambitious goal of including both the analog and digital functions in the same location on the detector. We also will add an analog multiplxer with a provision to read out a single analog signal ASDQ chip (we can read 2/chip). This involves the addition of an isolation transformer, and a bare-bones way to multiplex the signals so we don't have a billion cables coming up from the pit. This will be estimated by including another multiplexer for each plank.

Ground Rules & Assumptions:

Every channel's threshold can be set and checked and at least one analog signal on each ASDQ can be checked. The readout and digital compression will take place close to, but not on, each 32-channel board. There will be ribbon cables, loosely shielded, to convey the digital and analog information between the 32-channel board and the readout. We are planning 1 ribbon cable for each ASDQ chip.

Estimate Source:

Most of these items are directly from catalogs or have been purchased in the past.

Basis of Estimate:

The 8 channel ASDQ footprint and the 32 channel board footprint. The number of components used in the E687 straw electronics.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.1

WBS Element Name:

Development and Prototypes

WBS Element Definition:

We need to really determine which items are critical and not for the production board. For now we'll assume everything is important. There was much evidence in the test beam running that we could benefit from individual thresholds and improved noise immunity. Our goal will be to reap as much benefit from this experience as we can. We would like to prototype at least 20, 32 channel boards. We already have the software and expertise to lay out the circuit board.

Ground Rules & Assumptions:

We will budget for enough electronics to outfit 20, 32 channel cards. With some provision for spares.

Estimate Source:

Last summer's prototyping run expense, web page prices, catalog pricing, past purchases.

Basis of Estimate:

Cost of last summer's electronics and projected cost from the sources.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.1.1

WBS Element Name:

Analog Mux

WBS Element Definition:

We need to be able to verify the voltages on the board that are being delivered to the ASDQ threshold (1/channel) inputs. Rather than have one ADC channel for each threshold, we will multiplex the signals into two ADC channels for slow monitoring. The analog multiplexer we have tentatively chosen is the Texas Instruments CD74HC4067. This multiplexer has 16 channels/chip. This is an active commercial item.

Ground Rules & Assumptions:

Three 16 channel Mux chips will be needed. There are more voltages to monitor actually than just the threshold voltages. The added cost for including each part on the front end board for assembly is not included at this time.

Estimate Source:

Texas Instruments

Basis of Estimate:

Texas Instruments Web Site

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.1.2

WBS Element Name:

Octal DAC

WBS Element Definition:

In the real production board we will need a mechanism to supply threshold voltage to each channel of the ASDQ. Our experience in the test beam in the summer of 1999 was that we could benefit from individual thresholds for each channel. To set the thresholds we need DAC channels. There are an additional 2 channels/ASDQ chip needed for test functions.

Ground Rules & Assumptions:

We need enough DAC's 32 channels plus extra for test functions. The DAC,s will need to communicate via a serial channel that is compatible with the muon digital control and readout electronics. We will require 5 chips/ 32 channel board of the DAC's.

Estimate Source:

We will use catalog pricing for this part. The added cost for including each part on the front end board for assembly is not included at this time. The DAC we have tentatively chosen is the Texas Instruments DAC TLV5628ID. This particular DAC has 8 channels/chip and features a serial interface.

Basis of Estimate:

The cost of the integrated circuits, not including assembly costs, from the Texas Instruments web site.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.1.3

WBS Element Name:

11 input ADC

WBS Element Definition:

To review the thresholds we will need an ADC. The ADC we have chosen has 11 separate inputs and can be used to monitor more voltages than those that would be available via the analog mux. (e. g. High voltage, current etc.)

Ground Rules & Assumptions:

We need 1 ADC for each 32 channel board. The ADC will need to communicate via a serial channel that is compatible with the muon digital control and readout electronics.

Cost Estimate Source:

We will use catalog pricing for this part. The added cost for including each part on the front end board for assembly is not included at this time. The ADC we have tentatively chosen is the Texas Instruments TLV1543CD.

Basis of Cost Estimate:

The cost of the integrated circuits, not including assembly costs, from the Texas Instruments web site.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.1.4

WBS Element Name:

Wideband Transistor BFT92

WBS Element Definition:

This is a very nice 5 Ghz transistor from Phillips Semiconductor specification BFT92. We intend to use this along with another transistor to condition the input for enhanced noise immunity prior to the ASDQ input. This transistor and its companion, the BFT25 were used very successfully in the amplifier stage of the Straw electronics in E687. This is especially useful since the E687 electronics had a high power digital output stage.

Ground Rules & Assumptions:

We will need 32 transistors for each 32 channel board. The added cost for including each part on the front end board for assembly is not included at this time.

Estimate Source:

Phillip's semiconductor. A minimum purchase is a reel of 3000.

Basis of Estimate:

The Phillip's web site.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.1.5

WBS Element Name:

Wideband Transistor BFT25

WBS Element Definition:

This is a very nice 2 Ghz transistor from Phillips Semiconductor specification BFT25. We intend to use this along with another transistor to condition the input for enhanced noise immunity prior to the ASDQ input. This transistor and its companion, the BFT92 were used very successfully in the amplifier stage of the Straw electronics in E687. This is especially useful since the E687 electronics had a high power digital output stage.

Ground Rules & Assumptions:

We will need 32 transistors for each 32 channel board. The added cost for including each part on the front end board for assembly is not included at this time.

Cost Estimate Source:

Phillip's semiconductor. A minimum purchase is a reel of 3000.

Basis of Cost Estimate:

The Phillip's web site.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.1.6

WBS Element Name:

Protection Push-Pull Diode

WBS Element Definition:

This is the high speed switching diode from ZETEX specification BAV99ZXT that is used to protect the inputs of the amplifiers from voltage spikes. This is a nice item and it is especially pleasing to see that it has reduced in price by an order of magnitude over the last 5 years.

Ground Rules & Assumptions:

We will need 32 transistors for each 32 channel board. The added cost for including each part on the front end board for assembly is not included at this time.

Estimate Source:

Digikey

Basis of Estimate:

Digikey web site

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.1.7

WBS Element Name:

Misc. Components (resistors and Capacitors)

WBS Element Definition:

These are the inevitable resistors and capacitors that I have left out of the estimate by using the COT board for the baseline cost.

Ground Rules & Assumptions:

Roughly 10 components/channel will be needed extra, and this is most likely generous.

Estimate Source:

Catalog price for resistors and capacitors. (5 cents each). The added cost for including each part on the front end board for assembly is not included at this time.

Basis of Estimate:

Newark Catalog

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.1.8

WBS Element Name:

Analog Mux

WBS Element Definition:

We'll need another analog mux to deal with the analog readout of a few channels for monitoring purposes, and one at the other end to deal with the signals from other planks. I don't know what to do with this yet so I'm pricing an extra MUX /plank until I know better.

Ground Rules & Assumptions:

Well need one mux-like item for each 32 channel board.

Estimate Source:

Same as 1.5.4.1.1

Basis of Estimate:

Same as 1.5.4.1.1

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.1.9

WBS Element Name:

Isolation Transformer

WBS Element Definition:

We can't afford to create a ground problem with the analog cables, so we are going to break the ground before it has a chance to do harm.

Ground Rules & Assumptions:

We will need one isolation transformer for each ASDQ chip. These parts come in a quad configuration and we'll plan on using one chip for each 32 channel card. We actually already have some of these in hand, so we can go a little easy on the prototyping quantities.

Estimate Source:

These were used in the E831 (FOCUS) experiment and we have an older quote for them.

Basis of Estimate:

Actual purchase price from a previous production run.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.1.10

WBS Element Name:

Connectors and Cable

WBS Element Definition:

These are the twisted pair cables that connect the 32 channels of ASDQ output to the readout/serializer boards.

Ground Rules & Assumptions:

We will need one cable for each 2 ASDQ chips with enough extra conductors to convey analog and (slow) digital information for monitoring and parameter setting. We will price the cable complete with socket connectors on each end, but ultimately, we think one end will be a solder tail. Each cable will need be no more than 5 feet in length. Any shielding we need can be done home brew style as we did in the test beam running for less than a dollar a cable (negligible). We will get 60 cables for the prototyping as we expect to do lots of nasty things to these cables.

Estimate Source:

These are a mass produced catalog item. We got the price from the DIGIKEY catalog.

Basis of Estimate:

Digikey part M3AAA-4060K-ND.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.1.11

WBS Element Name:

Miscellaneous Digital Circuitry Components

WBS Element Definition:

This element describes development and prototyping of the auxiliary electronics needed to support the control/monitoring & timing and data readout electronics on the Muon data combiner board. This included design reviews, development time, and prototype debug time, and prototype component costs. Components will include VXO, PROM, 130 MHz XTAL, and four FPGAs that receive the parallel 416 channels of LVDS over threshold data, level translate to single ended, and serialize the data in groups of 12 via a serial shift register which is readout by the TMC^2.

Ground Rules & Assumptions:

Assume 416 channels of over threshold data per data combiner board.
Signal levels between the analog front end board and digital data combiner board are differential.
Assume reviews will take place either on-site at Fermilab, or via tele/video conference.

Estimate Source:

Fermilab, Electronic Systems Engineering Department personnel.
Vendor quotes from Xilinx sales representative.

Basis of Estimate:

Time estimates are based on historical experiences with projects of similar complexity.
Prototype component costs are based on present day pricing.
Level Translator/Serializer FPGAs are low speed grade Xilinx Spartan II series XC2S150 in a FG456 package.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.2

WBS Element Name:

Production

WBS Element Definition:

We will assume these items are critical for the production board. There was much evidence in the test beam running that we could benefit from individual thresholds and improved noise immunity. Our goal will be to reap as much benefit from this experience as we can. These items are expected to play a crucial role in the successful operation of the 32 channel board.

Ground Rules & Assumptions:

We will budget for enough electronics to outfit 2496, 32 channel cards. With some provision for spares.

Estimate Source:

Last summer's prototyping run expense, web page prices, catalog pricing, past purchases, and the prototyping costs listed above.

Basis of Estimate:

Cost of last summer's electronics and projected cost from the sources.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.2.1

WBS Element Name:

Analog Mux

WBS Element Definition:

We need to be able to verify the voltages on the board that are being delivered to the ASDQ threshold (1/channel) inputs. Rather than have one ADC channel for each threshold, we will multiplex the signals into two ADC channels for slow monitoring. The analog multiplexer we have tentatively chosen is the Texas Instruments CD74HC4067. This multiplexer has 16 channels/chip. This is an active commercial item.

Ground Rules & Assumptions:

Three 16 channel Mux chips will be needed. There are more voltages to monitor actually than just the threshold voltages. The added cost for including each part on the front end board for assembly is not included at this time.

Estimate Source:

Texas Instruments

Basis of Estimate:

Texas Instruments Web Site

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.2.2

WBS Element Name:

Octal DAC

WBS Element Definition:

In the real production board we will need a mechanism to supply threshold voltage to each channel of the ASDQ. Our experience in the test beam in the summer of 1999 was that we could benefit from individual thresholds for each channel. To set the thresholds we need DAC channels. There are an additional 2 channels/ASDQ chip needed for test functions.

Ground Rules & Assumptions:

We need enough DAC's 32 channels plus extra for test functions. The DAC,s will need to communicate via a serial channel that is compatible with the muon digital control and readout electronics. We will require 5 chips/ 32 channel board of the DAC's.

Estimate Source:

We will use catalog pricing for this part. The added cost for including each part on the front end board for assembly is not included at this time. The DAC we have tentatively chosen is the Texas Instruments DAC TLV5628ID. This particular DAC has 8 channels/chip and features a serial interface.

Basis of Estimate:

The cost of the integrated circuits, not including assembly costs, from the Texas Instruments web site.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.2.3

WBS Element Name:

11 input ADC

WBS Element Definition:

To review the thresholds we will need an ADC. The ADC we have chosen has 11 separate inputs and can be used to monitor more voltages than those that would be available via the analog mux.(e.g. High voltage, current etc.)

Ground Rules & Assumptions:

We need 1 ADC for each 32 channel board. The ADC will need to communicate via a serial channel that is compatible with the muon digital control and readout electronics.

Cost Estimate Source:

We will use catalog pricing for this part. The added cost for including each part on the front end board for assembly is not included at this time. The ADC we have tentatively chosen is the Texas Instruments TLV1543CD.

Basis of Cost Estimate:

The cost of the integrated circuits, not including assembly costs, from the Texas Instruments web site.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.2.4

WBS Element Name:

Wideband Transistor BFT92

WBS Element Definition:

This is a very nice 5 GHz transistor from Phillips Semiconductor specification BFT92. We intend to use this along with another transistor to condition the input for enhanced noise immunity prior to the ASDQ input. This transistor and its companion, the BFT25 were used very successfully in the amplifier stage of the Straw electronics in E687. This is especially useful since the E687 electronics had a high power digital output stage.

Ground Rules & Assumptions:

We will need 32 transistors for each 32 channel board. The added cost for including each part on the front end board for assembly is not included at this time.

Estimate Source:

Phillip's semiconductor. A minimum purchase is a reel of 3000.

Basis of Estimate:

The Phillip's web site.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.2.5

WBS Element Name:

Wideband Transistor BFT25

WBS Element Definition:

This is a very nice 2 GHz transistor from Phillips Semiconductor specification BFT25. We intend to use this along with another transistor to condition the input for enhanced noise immunity prior to the ASDQ input. This transistor and its companion, the BFT92 were used very successfully in the amplifier stage of the Straw electronics in E687. This is especially useful since the E687 electronics had a high power digital output stage.

Ground Rules & Assumptions:

We will need 32 transistors for each 32 channel board. The added cost for including each part on the front end board for assembly is not included at this time.

Cost Estimate Source:

Phillip's semiconductor. A minimum purchase is a reel of 3000.

Basis of Cost Estimate:

The Phillip's web site.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.2.6

WBS Element Name:

Protection Push-Pull Diode

WBS Element Definition:

This is the high speed switching diode from ZETEX specification BAV99ZXT that is used to protect the inputs of the amplifiers from voltage spikes. This is a nice item and it is especially pleasing to see that it has reduced in price by an order of magnitude over the last 5 years.

Ground Rules & Assumptions:

We will need 32 transistors for each 32 channel board. The added cost for including each part on the front end board for assembly is not included at this time.

Estimate Source:

Digikey

Basis of Estimate:

Digikey web site

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.2.7

WBS Element Name:

Misc. Components (resistors and Capacitors)

WBS Element Definition:

These are the inevitable resistors and capacitors that I have left out of the estimate by using the COT board for the baseline cost.

Ground Rules & Assumptions:

Roughly 10 components/channel will be needed extra, and this is most likely generous.

Estimate Source:

Catalog price for resistors and capacitors. (5 cents each). The added cost for including each part on the front end board for assembly is not included at this time.

Basis of Estimate:

Newark Catalog

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.2.8

WBS Element Name:

Analog Mux

WBS Element Definition:

We'll need another analog mux to deal with the analog readout of a few channels for monitoring purposes, and one at the other end to deal with the signals from other planks. I don't know what to do with this yet so I'm pricing an extra MUX /plank until I know better.

Ground Rules & Assumptions:

Well need one mux-like item for each 32 channel board.

Estimate Source:

Same as 1.5.4.2.1

Basis of Estimate:

Same as 1.5.4.2.1

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.2.9

WBS Element Name:

Isolation Transformer

WBS Element Definition:

We can't afford to create a ground problem with the analog cables, so we are going to break the ground before it has a chance to do harm.

Ground Rules & Assumptions:

We will need one isolation transformer for each ASDQ chip. These parts come in a quad configuration and we'll plan on using one chip for each 32 channel card.

Estimate Source:

These were used in the E831 (FOCUS) experiment and we have an older quote for them.

Basis of Estimate:

Actual purchase price from a previous production run.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.2.10

WBS Element Name:

Connectors and Cable

WBS Element Definition:

These are the twisted pair cables that connect the 32 channels of ASDQ output to the readout/serializer boards.

Ground Rules & Assumptions:

We will need one cable for each 2 ASDQ chips with enough extra conductors to convey analog and (slow) digital information for monitoring and parameter setting. We will price the cable complete with socket connectors on each end, but ultimately, we think one end will be a solder tail. Each cable will need be no more than 5 feet in length. Any shielding we need can be done home brew style as we did in the test beam running for less than a dollar a cable (negligible).

Estimate Source:

These are a mass produced catalog item. We got the price from the DIGIKEY catalog.

Basis of Estimate:

Digikey part M3AAA-4060K-ND.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.4.2.11

WBS Element Name:

Miscellaneous Digital Circuitry Components

WBS Element Definition:

This element describes the production auxiliary electronics needed to support the control/monitoring & timing and data readout electronics on the Muon data combiner board. This included design reviews, development time, and prototype debug time, and prototype component costs. Components will include VXO, PROM, 130 MHz XTAL, and four FPGAs that receive the parallel 416 channels of LVDS over threshold data, level translate to single ended, and serialize the data in groups of 12 via a serial shift register which is readout by the TMC^2.

Ground Rules & Assumptions:

Assume 416 channels of over threshold data per data combiner board.
Signal levels between the analog front end board and digital data combiner board are differential.
Assume reviews will take place either on-site at Fermilab, or via tele/video conference.

Estimate Source:

Fermilab, Electronic Systems Engineering Department personnel

Basis of Estimate:

Time estimates are based on historical experiences with projects of similar complexity.
Level translator/serializer FPGA component costs based on anticipated pricing for production quantities of low speed grade Xilinx Spartan II Series XC2S150 in a FG456 package in FY2004. Historical pricing data trends of components of relative same complexity used to extrapolate pricing into FY2004.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.5

WBS Element Name:

32-Channel Amplifier/Discriminator Boards

WBS Element Definition:

On this printed circuit board we combine the ASDQ's the DAC's, and all the transistors, resistors and capacitors etc. we need to process the small signals coming from the proportional tubes. The cost for producing the boards is based on the cost of fabricating and assembling the CDF COT cards. That is why fabrication and assembly are included in one item.

Ground Rules & Assumptions:

Each group of 32 channels will need one PC board for the ASDQ related functions.

Estimate Source:

Experience with the COT board. Setup charges from other boards.

Basis of Estimate:

Old P.O.'s, e-mail from University of Pennsylvania.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.5.1

WBS Element Name:

Development and Prototypes

WBS Element Definition:

Here we will list the expenses we plan to incur as a result of determining the best selection of components and the layout for the 32 channel board. We would like to produce 20 boards at the prototyping stage, and we will assume we'll need 3 prototyping cycles of 5 cards each to get things correct. For the prototyping cycles we will use our experience and actual cost for the prototype boards used in the test beam running in the summer of 1999.

Ground Rules & Assumptions:

Each group of 32 channels will need one PC board for the ASDQ related functions. To determine prototyping cost we will estimate the expense from the production of the 16 channel ASD8B card and double the number of cards we need to produce.

Estimate Source:

Experience with the ASD8B board. Setup charges from other boards.

Basis of Estimate:

Old P.O.'s, e-mail from University of Pennsylvania.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.5.1.1

WBS Element Name:

Fabrication and Assembly

WBS Element Definition:

Here we will outlay the separate costs involved in making the circuit board. There are one time charges associated with short runs and we need to include them. And there are costs associated with testing each cycle.

Ground Rules & Assumptions:

We will need 3 prototyping cycles. Each cycle will produce 5 boards of 32 channels each. An additional 5 boards of the most successful prototype will be fabricated as well.

Estimate Source:

Experience with the COT board. Setup charges from other boards. Experience with the ASD8B card used in the summer test beam.

Basis of Estimate:

Old P.O.'s, e-mail from University of Pennsylvania.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.5.1.1.1

WBS Element Name:

Set-up Charge (Fabrication)

WBS Element Definition:

When We actually get our own board fabricated for the prototype, we will have to pay the board manufacturer for the expense to set up the fabrication machine. The ASD8B board had already been fabricated so we lucked out on that expense for the summer test beam running. The estimate is base on the set-up charge for other boards of a similar size and complexity.

Ground Rules & Assumptions:

There will be one set-up charge associated with each prototyping run. Three separate runs are very reasonable to get the board right.

Estimate Source:

Experience with other boards.

Basis of Estimate:

Old P.O.'s

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.5.1.1.2

WBS Element Name:

Set-up Charge (Assembly)

WBS Element Definition:

When we are happy with a fabricated prototype. We will want to try to have one machine assembled to test the production. We might have to do this more than once, but we've had fairly good luck in the past. The added cost of a set –up for machine assembly was not included in the ASD8B board since it was assembled by hand.

Ground Rules & Assumptions:

We will need at least one set-up. We will budget for three.

Estimate Source:

Past experience with a board of similar complexity.

Basis of Estimate:

Old P.O.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.5.1.1.3

WBS Element Name:

Testing Jigs

WBS Element Definition:

In order to test whether or not the boards are acceptable at the production level, and to ensure that we are making the right prototypes, some specialized test equipment is useful. This will entail making some simple cards to pule inputs and read out signals. We will attempt to automate the tests as much as possible using PC based DAQ and I/O using a commercial package like LABVIEW (which we already have). Purchasing I/O cards and simple boards are the anticipated expenses.

Ground Rules & Assumptions:

We will need to test the cards we make and set up production tests. (~3) $500 cards and several (~5) specialized circuit boards will probably need to be designed and built.

Estimate Source:

$500/card and $400/specialized board

Basis of Estimate:

National Instruments Web site and past experience.

BTeV WBS Dictionary

Basis of Cost Estimate

WBS Element Number:

1.5.2.5.1.1.4

WBS Element Name:

Prototype ASDQ Front End Board

WBS Element Definition:

This is what we expect to pay for a fully stuffed and ready to go 32 channel board.

Ground Rules & Assumptions:

We will need one front end board for each group of 32 channels. Recall that 32 channels comprise a plank. Since the cards we used in the test beam had 16 channels each, and we want to build enough cards for 640 channels (20 x 32), we are basing the estimate on 40 16-channel cards.

Cost Estimate Source:

The cost will be based on our actual cost for the card used in the summer test beam. We bought them from the University of Pennsylvania and all costs were included except the set-up charges.

Basis of Cost Estimate:

Old P.O.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.5.2

WBS Element Name:

Production

WBS Element Definition:

Here we will list the expenses we plan to incur during the production of the 32 channel cards. The cost of this card will include components needed for supplying power to the ASDQ and the connectors needed for signal i/o. The costs for production come from the production of the COT cards for CDF.

Ground Rules & Assumptions:

Each group of 32 channels will need one PC board for the ASDQ related functions. We will make 2496 cards with some provision for spares. Since the COT card is a 24 channel card, we have inflated the production cost by a factor of 1.25 to cover the additional 8 channels.

Estimate Source:

E-mail from University of Pennsylvania. Setup charges from other boards.

Basis of Estimate:

1450 COT cards at a production cost of $44,000 with our inflation factor of 1.25. Setup charges as before (you don't always get the cheapest production cost from your prototype house!)

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.5.2.1

WBS Element Name:

Fabrication and Assembly

WBS Element Definition:

Here we will outlay the separate costs involved in making the circuit board. There are one time charges associated with set up and we need to include them in case the vendor requires it.

Ground Rules & Assumptions:

We will be fabricating and assembling 2496, 32 channel boards with provisions for spares.

Estimate Source:

Experience with the COT board. Setup charges from other boards

Basis of Estimate:

Old P.O.'s, e-mail from University of Pennsylvania.(see above)

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.5.2.1.1

WBS Element Name:

Set-up Charge (Fabrication)

WBS Element Definition:

When we actually get our own board fabricated, we will have to pay the board manufacturer for the expense to set up the fabrication machine. The estimate is base on the set-up charge for other boards of a similar size and complexity.

Ground Rules & Assumptions:

There will be one set-up charge associated with the boards. Three separate runs are very reasonable to get the board right.

Estimate Source:

Experience with other boards.

Basis of Estimate:

Old P.O.'s

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.5.2.1.2

WBS Element Name:

Set-up Charge (Assembly)

WBS Element Definition:

The added cost of a setup for machine assembly was not included in the ASDQ COT board.

Ground Rules & Assumptions:

We will need at least one setup.

Estimate Source:

Past experience with a board of similar complexity.

Basis of Estimate:

Old P.O.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.5.2.1.3

WBS Element Name:

Testing Jigs

WBS Element Definition:

In order to test whether or not the boards are acceptable at the production level, and to ensure that we are making the right prototypes, some specialized test equipment is useful. This will entail making some simple cards to pule inputs and read out signals. We will attempt to automate the tests as much as possible using PC based DAQ and I/O using a commercial package like LABVIEW (which we already have). Purchasing I/O cards and simple boards are the anticipated expenses.

Ground Rules & Assumptions:

We will need to test the cards we make and set up production tests. (1) $500 cards and several (~5) specialized circuit boards will probably need to be designed and built. We are anticipating the need for some modifications or enhancements for the production board testing (i.e. we may want to have a testing jig at the assembler)

Estimate Source:

$500/card and $400/specialized board

Basis of Estimate:

National Instruments Web site and past experience.

BTeV WBS Dictionary

Basis of Cost Estimate

WBS Element Number:

1.5.2.5.2.1.4

WBS Element Name:

Production ASDQ Front End Board

WBS Element Definition:

This is what we expect to pay for a fully stuffed and ready to go 32 channel board.

Ground Rules & Assumptions:

We will need one front end board for each group of 32 channels. Recall that 32 channels comprise a plank. This cost includes fabrication, stuffing, and a few components not previously mentioned such as i/o connectors.

Cost Estimate Source:

The cost will be based on the actual cost for the card used in the CDF COT. We got the estimate from the University of Pennsylvania.

Basis of Cost Estimate:

E-mail from University of Pennsylvania. 1450 COT cards at a production cost of $44,000 with our inflation factor of 1.25.(see above)

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6

WBS Element Name:

Plank Interface Cards

WBS Element Definition:

These are the cards that we use to seal the brass gas manifold completing an EMI shield for the tubes, convey the high voltage to the tube wire, terminate the signal at the non-readout end, and ac couple the wire to the amplifying electronics. We will attempt to make these cards as simple as possible.

Ground Rules & Assumptions:

We will need at least 2 cards for every 32 channel plank.

Estimate Source:

We will base our cost on our production and prototyping for the 1999 summer test beam.

Basis of Estimate:

Old purchases, catalog items.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.1

WBS Element Name:

Prototype Plank Interface Cards

WBS Element Definition:

These cards convey the signals from the proportional tubes to the front-end cards, provide a connection for HV bias, and on the non-signal read out end, provide a termination for the tube. These boards also provide the gas seal at the end of the gas manifold. As we have re-designed the mechanical structure of the system to combat EMI, we need to redesign and test these cards too. Our time estimate includes hand assembly of components and the time needed to solder a completed board to the gas manifold. The extra spares are needed since we have to remove this card if there is a broken wire to replace.

Ground Rules & Assumptions:

There are two types of cards that need to be made. One card for the signal/HV end and one for the termination end. One of each type is needed to outfit a plank of 32 proportional tube channels.

Estimate Source:

Our actual cost at producing prototypes for the summer 1999 running in the test beam, the labor involved from experience and additional parts.

Basis of Estimate:

Our cost, past experience and quotes.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.1.1

WBS Element Name:

Prototype HV Bias and Signal Board

WBS Element Definition:

This is the PC board we used to bias the proportional tubes with HV and also to read out the signals. This is a very simple board with 2 metal layers. We had to our own coating (RTV) and machine the boards ourselves. We'd like to prototype a board where the vendor does as much labor as possible (i.e. machining and board coating)

Ground Rules & Assumptions:

We need one of these boards for each plank. Board machining and coating are a separate expense.

Estimate Source:

Actual cost.

Basis of Estimate:

Old Purchase Order

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.1.2

WBS Element Name:

HV Blocking Capacitor

WBS Element Definition:

We need this capacitor to read out the positively biased signal wires. This one is the tried and true 3K Sprague 30GA-D10.

Ground Rules & Assumptions:

We need 1 cap for each channel and one extra so that we'll have an ac filter for the main HV line.

Estimate Source:

Newark part number 46f5277

Basis of Estimate:

Newark Catalog

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.1.3

WBS Element Name:

HV Resistor

WBS Element Definition:

We need a way to isolate signals from talking on the HV bus and a way to prevent one bad channel from ruining the HV bias for a whole plank. Right now the best way we know how to do this is with a big resistor. The Victoreen division of OHMITE makes a very nice high voltage resistor MC101 available in surface mount.

Ground Rules & Assumptions:

We need 1 resistor for each channel and an extra 2 for each group of 32 channels to use as part of an ac filter.

Estimate Source:

Victoreen division of OHMITE for part MC101

Basis of Estimate:

Quote from Victoreen.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.1.4

WBS Element Name:

Signal Connector

WBS Element Definition:

This is the connector that mates with the connector on the front-end board.

Ground Rules & Assumptions:

We need enough pins to convey both signal and HV with HV well separated from signal.

Estimate Source:

Digikey Part number SPE1026-ND

Basis of Estimate:

Digikey catalog

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.1.5

WBS Element Name:

Board Coating

WBS Element Definition:

This is the high dielectric strength coating we'll use on the board to prevent sparking and to keep the board surface sealed from moisture as much as possible.

Ground Rules & Assumptions:

Each board will need to be coated.

Estimate Source:

Best we have right now is from gooping high dielectric strength RTV on each board.

Basis of Estimate:

RTV cost from Fermilab Stock room and board yield/tube.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.1.6

WBS Element Name:

Solder

WBS Element Definition:

These boards will require a lot of solder, and we may need to use something special for the gas manifold.

Ground Rules & Assumptions:

This is a per board estimate for a specialty type solder at 0.5 oz. of solder/board.

Estimate Source:

SN 62 no clean solder, Newark part number 00Z1336.

Basis of Estimate:

Newark catalog

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.1.7

WBS Element Name:

Board Machining

WBS Element Definition:

Each board needs to be fit into a machined space on the gas manifold. When we Prototype again, we will have the board manufacturer do this. For now, we will use our experience in machining the prototype to set the expense.

Ground Rules & Assumptions:

Each board will need to be machined.

Estimate Source:

10 minutes of Vanderbilt Shop Time

Basis of Estimate:

Vanderbilt shop rate of $30/hr

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.1.8

WBS Element Name:

Prototype Termination Card

WBS Element Definition:

This is the PC board we used to terminate the signals with the characteristic impedance of the proportional tube on the end opposite the signal readout. This is a very simple board with 2 metal layers. We had to our own coating (RTV) and machine the boards ourselves.

Ground Rules & Assumptions:

We need one of these boards for each plank. Board machining and coating are a separate expense.

Estimate Source:

Actual cost.

Basis of Estimate:

Old Purchase Order

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.1.9

WBS Element Name:

HV Blocking Capacitor

WBS Element Definition:

We need this capacitor to shunt the signal from the positively biased signal wires into the termination resistor. This one is the tried and true 3K Sprague 30GA-D10.

Ground Rules & Assumptions:

We need 1 cap for each channel.

Estimate Source:

Newark part number 46f5277

Basis of Estimate:

Newark Catalog

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.1.10

WBS Element Name:

Resistors

WBS Element Definition:

These are the ~300 ohm surface mount termination resistors.

Ground Rules & Assumptions:

We need 1 resistor for each.

Estimate Source:

Digikey Part P301FCT-ND

Basis of Estimate:

Digikey Catalog

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.1.11

WBS Element Name:

Solder

WBS Element Definition:

These boards will require a lot of solder, and we may need to use something special for the gas manifold.

Ground Rules & Assumptions:

This is a per board estimate for a specialty type solder at 0.5 oz. of solder/board.

Estimate Source:

SN 62 no clean solder, Newark part number 00Z1336.

Basis of Estimate:

Newark catalog

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.1.12

WBS Element Name:

Board Machining

WBS Element Definition:

Each board needs to be fit into a machined space on the gas manifold. When we prototype again, we will have the board manufacturer do this. For now, we will use our experience in machining the prototype to set the expense.

Ground Rules & Assumptions:

Each board will need to be machined.

Estimate Source:

10 minutes of Vanderbilt Shop Time

Basis of Estimate:

Vanderbilt shop rate of $30/hr

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.1.13

WBS Element Name:

Board Coating

WBS Element Definition:

This is the high dielectric strength coating we'll use on the board to prevent sparking and to keep the board surface sealed from moisture as much as possible.

Ground Rules & Assumptions:

Each board will need to be coated.

Estimate Source:

Best we have right now is from gooping high dielectric strength RTV on each board.

Basis of Estimate:

RTV cost from Fermilab Stock room and board yield/tube.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.1.14

WBS Element Name:

Testing Jigs

WBS Element Definition:

These are a few simple stands we can use to see if our components are good and as soldering aids for putting the boards on and for measuring/verifying/fixing the board machining.

Ground Rules & Assumptions:

Need a couple real simple jigs. Probably nothing more than a board with sockets for a high pot test, a machined block to test the board size, and maybe a fixture to place components easily.

Estimate Source:

Experience making other jigs, about an hour of shop time.

Basis of Estimate:

Vanderbilt shop rate of $30/hr

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.2

WBS Element Name:

Production Plank Interface Cards

WBS Element Definition:

These cards convey the signals from the proportional tubes to the front-end cards, provide a connection for HV bias, and on the non-signal read out end, provide a termination for the tube. These boards also provide the gas seal at the end of the gas manifold. As we have re-designed the mechanical structure of the system to combat EMI, we need to redesign and test these cards too. Our time estimate includes hand assembly of components and the time needed to solder a completed board to the gas manifold. The extra spares are needed since we have to remove this card if there is a broken wire to replace. Our experience is that it is better to replace the card than to reuse it. We have included an extra 10% spares to produce our first quad of planks.

Ground Rules & Assumptions:

There are two types of cards that need to be made. One card for the signal/HV end and one for the termination end. One of each type is needed to outfit a plank of 32 proportional tube channels.

Estimate Source:

Our actual cost at producing prototypes for the summer 1999 running in the test beam, the labor involved from experience and additional parts.

Basis of Estimate:

Our cost, past experience and quotes.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.2.1

WBS Element Name:

HV Bias and Signal Board

WBS Element Definition:

This is the PC board we used to bias the proportional tubes with HV and also to read out the signals. This is a very simple board with 2 metal layers. We had to our own coating (RTV) and machine the boards ourselves.

Ground Rules & Assumptions:

We need one of these boards for each plank. Board machining and coating are a separate expense.

Estimate Source:

Actual cost.

Basis of Estimate:

Old Purchase Order

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.2.2

WBS Element Name:

HV Blocking Capacitor

WBS Element Definition:

We need this capacitor to read out the positively biased signal wires. This one is the tried and true 3K Sprague 30GA-D10.

Ground Rules & Assumptions:

We need 1 cap for each channel and one extra so that we'll have an ac filter for the main HV line.

Estimate Source:

Newark part number 46f5277

Basis of Estimate:

Newark Catalog

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.2.3

WBS Element Name:

HV Resistor

WBS Element Definition:

We need a way to isolate signals from talking on the HV bus and a way to prevent one bad channel from ruining the HV bias for a whole plank. Right now the best way we know how to do this is with a big resistor. The Victoreen division of OHMITE makes a very nice high voltage resistor MC101 available in surface mount.

Ground Rules & Assumptions:

We need 1 resistor for each channel and an extra 2 for each group of 32 channels to use as part of an ac filter.

Estimate Source:

Victoreen division of OHMITE for part MC101

Basis of Estimate:

Quote from Victoreen.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.2.4

WBS Element Name:

Signal Connector

WBS Element Definition:

This is the connector that mates with the connector on the front-end board.

Ground Rules & Assumptions:

We need enough pins to convey both signal and HV with HV ell separated from signal.

Estimate Source:

Digikey Part number SPE1026-ND

Basis of Estimate:

Digikey catalog

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.2.5

WBS Element Name:

Board Coating

WBS Element Definition:

This is the high dielectric strength coating we'll use on the board to prevent sparking and to keep the board surface sealed from moisture as much as possible.

Ground Rules & Assumptions:

Each board will need to be coated.

Estimate Source:

Best we have right now is from gooping high dielectric strength RTV on each board.

Basis of Estimate:

RTV cost from Fermilab Stock room and board yield/tube.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.2.6

WBS Element Name:

Solder

WBS Element Definition:

These boards will require a lot of solder, and we may need to use something special For the gas manifold.

Ground Rules & Assumptions:

This is a per board estimate for a specialty type solder at 0.5 oz. of solder/board.

Estimate Source:

SN 62 no clean solder, Newark part number 00Z1336.

Basis of Estimate:

Newark catalog

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.2.7

WBS Element Name:

Board Machining

WBS Element Definition:

Each board needs to be fit into a machined space on the gas manifold. When we prototype again, we will have the board manufacturer do this. For now, we will use our experience in machining the prototype to set the expense.

Ground Rules & Assumptions:

Each board will need to be machined.

Estimate Source:

10 minutes of Vanderbilt Shop Time

Basis of Estimate:

Vanderbilt shop rate of $30/hr

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.2.8

WBS Element Name:

Production Termination Card

WBS Element Definition:

This is the PC board we used to terminate the signals with the characteristic impedance of the proportional tube on the end opposite the signal readout. This is a very simple board with 2 metal layers. We had to our own coating (RTV) and machine the boards ourselves.

Ground Rules & Assumptions:

We need one of these boards for each plank. Board machining and coating are a separate expense.

Estimate Source:

Actual cost.

Basis of Estimate:

Old Purchase Order

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.2.9

WBS Element Name:

HV Blocking Capacitor

WBS Element Definition:

We need this capacitor to shunt the signal from the positively biased signal wires into the termination resistor. This one is the tried and true 3K Sprague 30GA-D10.

Ground Rules & Assumptions:

We need 1 cap for each channel.

Estimate Source:

Newark part number 46f5277

Basis of Estimate:

Newark Catalog

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.2.10

WBS Element Name:

Resistors

WBS Element Definition:

These are the ~300 ohm surface mount termination resistors.

Ground Rules & Assumptions:

We need 1 resistor for each.

Estimate Source:

Digikey Part P301FCT-ND

Basis of Estimate:

Digikey Catalog

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.2.11

WBS Element Name:

Solder

WBS Element Definition:

These boards will require a lot of solder, and we may need to use something special for the gas manifold.

Ground Rules & Assumptions:

This is a per board estimate for a specialty type solder at 0.5 oz. of solder/board.

Estimate Source:

SN 62 no clean solder, Newark part number 00Z1336.

Basis of Estimate:

Newark catalog

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.2.12

WBS Element Name:

Board Machining

WBS Element Definition:

Each board needs to be fit into a machined space on the gas manifold. When we prototype again, we will have the board manufacturer do this. For now, we will use our experience in machining the prototype to set the expense.

Ground Rules & Assumptions:

Each board will need to be machined.

Estimate Source:

10 minutes of Vanderbilt Shop Time

Basis of Estimate:

Vanderbilt shop rate of $30/hr

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.6.2.13

WBS Element Name:

Board Coating

WBS Element Definition:

This is the high dielectric strength coating we'll use on the board to prevent sparking and to keep the board surface sealed from moisture as much as possible.

Ground Rules & Assumptions:

Each board will need to be coated.

Estimate Source:

Best we have right now is from gooping high dielectric strength RTV on each board.

Basis of Estimate:

RTV cost from Fermilab Stock room and board yield/tube.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.7

WBS Element Name:

Front –End EMI Enclosure

WBS Element Definition:

Our experience with the test beam showed that we need to keep the shielding around the ASD chips as tight as possible to get the best performance. For the test beam the shielding was ad-hoc with tape and PC board and was not very reliable. This time we're making the EMI shield an inherent part of the detector. To accomplish this we are going to try to modify an existing commercial item, but we think that making it ourselves will cost the same. We just haven't had the time to check it out yet!

Ground Rules & Assumptions:

Each 32 channel board will need to be enclosed in a shielded box.

Estimate Source:

Vanderbilt Shop. Catalog items.

Basis of Estimate:

Vanderbilt shop rate of $30/hr, catalog prices.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.7.1

WBS Element Name:

Aluminum Enclosure Prototype

WBS Element Definition:

This is the metal box that we will machine to accommodate the connection to the plank and the signal/voltage cables as well as the 32 channel card. It provides the EMI shield for the 32-channel card.

Ground Rules & Assumptions:

We need one box for each 32 channel card and the first one is going to be the most difficult. This means 15 boxes with some provision for spares to screw up.

Estimate Source:

Newark Catalog

Basis of Estimate:

Newark part 83F8748

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.7.2

WBS Element Name:

Enclosure Hardware

WBS Element Definition:

These are miscellaneous bolts nuts screws and banana jacks we need to mount and support the card inside of the EMI box.

Ground Rules & Assumptions:

We will need some screws and banana jacks for each box.

Estimate Source:

Glancing in Catalogs, experience.

Basis of Estimate:

Small stuff, about 2 bucks a box.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.7.3

WBS Element Name:

Enclosure Machining

WBS Element Definition:

We have to modify the off the shelf boxes (or whatever we choose to use). There will be a bit of development for each box iteration and we will probably need several iterations.

Ground Rules & Assumptions:

Each prototype box will take, on average, about 100 minutes of shop time.

Estimate Source:

Vanderbilt University machine shop

Basis of Estimate:

Shop rate of $30 /hr

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.7.4

WBS Element Name:

Aluminum Enclosure Production

WBS Element Definition:

This is the metal box that we will machine to accommodate the connection to the plank and the signal/voltage cables as well as the 32 channel card. It provides the EMI shield for the 32-channel card.

Ground Rules & Assumptions:

We need one box for each 32 channel card and the first one is going to be the most difficult. We will need 2496 boxes with some provision for spares.

Estimate Source:

Newark Catalog

Basis of Estimate:

Newark part 83F8748

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.7.5

WBS Element Name:

Enclosure Hardware

WBS Element Definition:

These are miscellaneous bolts nuts screws and banana jacks we need to mount and support the card inside of the EMI box.

Ground Rules & Assumptions:

We will need some screws and banana jacks for each box.

Estimate Source:

Glancing in Catalogs, experience.

Basis of Estimate:

Small stuff, about 2 bucks a box.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.7.6

WBS Element Name:

Enclosure Machining

WBS Element Definition:

We have to modify the off the shelf boxes (or whatever we choose to use) to accommodate the card and the connections to the card.

Ground Rules & Assumptions:

Each production box will take, on average, about 40 minutes of shop time.

Estimate Source:

Vanderbilt University machine shop

Basis of Estimate:

Shop rate of 30 dollars/hr

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.8

WBS Element Name:

416-Channel Data Combiner Boards

WBS Element Definition:

This element describes the Muon data combiner board manufacturing and assembly costs. The Muon data combiner boards will be assembled with the components needed to readout 416 (13 planks at 32 channels per plank) Muon front end detector channels and be controlled and monitored with the controls and monitoring system.

Ground Rules & Assumptions:

Assume 416 channel data combiner boards. Total Muon system channel count is 69120.

Estimate Source:

Historical vendor quotes for boards of similar complexity.
Fermilab, Electronic Systems Engineering Department personnel.

Basis of Estimate:

Prototype board costs are based historical costs of boards of similar complexity for prototype quantities.
Production board costs are based historical costs of boards of similar complexity for production quantities.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.8.1

WBS Element Name:

Development and Prototypes

WBS Element Definition:

This element describes the prototype Muon data combiner board manufacturing and assembly costs. The Muon data combiner boards will be assembled with the components needed to readout Muon front end detector channels and be controlled and monitored with the controls and monitoring system. Costs also include reviews.

Ground Rules & Assumptions:

Prototyping will considered complete when the prototype Muon front end board meets the performance requirement of the production front end board.

Estimate Source:

Historical vendor quotes for boards of similar complexity.
Fermilab, Electronic Systems Engineering Department personnel.

Basis of Estimate:

Prototype board costs are based historical costs of boards of similar complexity for prototype quantities.
Time estimates are based on historical experiences with projects of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.2.8.2

WBS Element Name:

Production

WBS Element Definition:

This element describes the production Muon data combiner board manufacturing and assembly costs. The Muon data combiner boards will be assembled with the components needed to readout 416 Muon front end detector channels and be controlled and monitored with the controls and monitoring system. Costs also include reviews.

Ground Rules & Assumptions:

Assume 416 channel data combiner boards. Total Muon system channel count is 69120.

Estimate Source:

Historical vendor quotes for boards of similar complexity.
Fermilab, Electronic Systems Engineering Department personnel.

Basis of Estimate:

Production board costs are based historical costs of boards of similar complexity for production quantities.
Time estimates are based on historical experiences with projects of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3

WBS Element Name:

Power & Cooling

WBS Element Definition:

These are the systems that provide low voltage, high voltage and cooling to the muon front-end electronics.

Ground Rules & Assumptions:

We will base the low voltage system on muon detector plane octants. That is, each power supply should be capable of delivering enough power for an entire 1/8 of a detector plane or about 13 planks. I have assumed that the power consumption of the front-end board will be the power consumption of the ASD8B prototype board times two with added power form the proposed added components. I am also allowing a factor of 2 to account for any digital power consumption that occurs.

Estimate Source:

Most of the pricing is from commercial sources while the time estimates are based on experience. Usually the longest time is spent in making the cables for the low voltage systems.

Basis of Estimate:

Verbal quotes for the high voltage, catalog prices elsewhere.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.1

WBS Element Name:

High Voltage

WBS Element Definition:

This is the cost for a conventional mainframe type high voltage system. When the CAEN representative visited Fermilab in November of 1999, we asked them for the cheapest price on a no-frills system for the muon electronics.

Ground Rules & Assumptions:

We asked to have 1 channel of high voltage for each plank of 32 channels.

Cost Estimate Source:

CAEN Representative, Catalog prices, labor in setting up a system based on experience.

Basis of Cost Estimate:

Verbal quotes (witnessed by Ed Barsotti and Will Johns)

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.1.1

WBS Element Name:

CAEN Basic System

WBS Element Definition:

This is the cheapest system that CAEN could offer us that let us control each channel of high voltage.

Ground Rules & Assumptions:

One channel of high voltage for each group of 32 channels

Estimate Source:

CAEN representative

Basis of Estimate:

Verbal Quote

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.1.2

WBS Element Name:

High Voltage Cable

WBS Element Definition:

This is the cost for a 40 foot High voltage cable (less labor) with SHV connectors on each end.

Ground Rules & Assumptions:

We need one cable for each plank of 32 channels

Cost Estimate Source:

Cable is 0.25/ft in the Newark catalog (Newark part 03F2471), and SHV Connectors are 16.10 apiece (Newark part 89F3379).

Basis of Cost Estimate:

Newark Catalog

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.1.3

WBS Element Name:

High Voltage Connectors

WBS Element Definition:

These are the ends to plug the SHV's into. There's a special plug coming out of the CAEN HV we need to interface to with these.

Ground Rules & Assumptions:

We'll need 2 of these for each group of 32 channels or plank.

Estimate Source:

Newark Part 89F3394

Basis of Estimate:

Newark Catalog

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.2

WBS Element Name:

Low Voltage

WBS Element Definition:

This is the power supplied to the font-end boards. A back of the envelope calculation shows that the maximum power each front end will draw is 4.5 watts. If all planks in an octant drew maximum power we would need a power supply capable of delivering 60 Watts (13 32 channel planks drawing 4.5 watts each). To be conservative, we will price 100W linear supplies that deliver 100 W so as to account for the power needed by the BTeV standard back end.

Ground Rules & Assumptions:

Each power supply must be capable of delivering 100W of power. This power will be converted on the front-end board. A DC-DC converter will be used to attain the voltage required by the ASDQ and ancillary logic.

Estimate Source:

Stock items from catalogs with labor estimates based on experience.

Basis of Estimate:

Catalogs and experience.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.2.1

WBS Element Name:

Low Voltage Prototype System

WBS Element Definition:

We will try to find the lowest cost system that satisfies our needs. We will have to start out with something nice and move steadily noisier/cheaper.

Ground Rules & Assumptions:

We'll need one 12V power supply to start out with. Maybe one or 2 later depending on what we find.

Estimate Source:

Largely catalog items. Most of the labor will be testing and developing cable construction methods.

Basis of Estimate:

Catalogs and experience.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.2.1.1

WBS Element Name:

DC-DC converter

WBS Element Definition:

This lets us break the ground and de-couple one front end board from another to stop system-wide oscillations before they get out of control. The unit will be very small and can fit on the front end board as well.

Ground Rules & Assumptions:

The DC-DC converter delivers +/-5V with sufficient power. We need two DC-DC converters for each front-end board. One to handle the Analog, one to handle the digital

Estimate Source:

This is the very small DC-DC converter from Newport Components. Newark carries these, Newport part number NMXD1205U.

Basis of Estimate:

Newark phone quote.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.2.1.2

WBS Element Name:

12V Power Supply

WBS Element Definition:

This is the unit that will supply power to those DC-DC converters. We would like to start with the best and go noisier. Need one that puts out 100 W of +12 V. We would also like to try a power supply that is a little noisier too.

Ground Rules & Assumptions:

We need one power supply for each group of 13 front-end boards. The power supply must be capable of delivering 100 W of +12 V power DC.

Estimate Source:

Sola power supply 83-12-310-3(-2) which is Newark part number 05f1134

Basis of Estimate:

Newark catalog.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.2.1.3

WBS Element Name:

Power Cable

WBS Element Definition:

This is the cable that carries power from the power supply to the front ends. It should be a shielded pair capable of carrying 0.5 A.

Ground Rules & Assumptions:

We need one power cable for each Front-end

Estimate Source:

This is Newark Model 03F2960 shielded pair.

Basis of Estimate:

Newark Catalog.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.2.1.4

WBS Element Name:

Plugs and connectors

WBS Element Definition:

These are solderless connectors for terminal strips, terminal strips and banana jacks and plugs for the power cable hook up. Don't have to be very fancy. Also the AC line for the DC supply.

Ground Rules & Assumptions:

We need some connectors for each front-end board to hook up the 12 V power and a power cord to hook up the DC supply to AC.

Estimate Source:

Survey of likely items from Newark.

Basis of Estimate:

Newark Catalog.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.2.2

WBS Element Name:

Low Voltage Production System

WBS Element Definition:

It the prototype works out, and we'll assume it does, this is the expect5ed cost for scaling up the prototype low volts.

Ground Rules & Assumptions:

We'll need one 12V power supply for each group of 13 front end boards. The power supply must be able to deliver 100 W of power at 12 V DC. The labor estimates come from experience. Most of the labor is in the cable making.

Estimate Source:

Largely catalog items. Most of the labor will be testing and developing cable construction methods.

Basis of Estimate:

Catalogs and experience.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.2.2.1

WBS Element Name:

DC-DC converter

WBS Element Definition:

This lets us break the ground and de-couple one front end board from another to stop system-wide oscillations before they get out of control. The unit will be very small and can fit on the front end board as well.

Ground Rules & Assumptions:

The DC-DC converter delivers +/-5V with sufficient power. We need two DC-DC converters for each front-end board. One to handle the Analog, one to handle the digital

Estimate Source:

This is the very small DC-DC convertor from Newport Components. Newark carries these, Newport part number NMXD1205U.

Basis of Estimate:

Newark phone quote.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.2.2.2

WBS Element Name:

12V Power Supply

WBS Element Definition:

This is the unit that will supply power to those DC-DC converters. Need one that puts out 100 W of +12 V.

Ground Rules & Assumptions:

We need one power supply for each group of 13 front-end boards. The power supply must be capable of delivering 100 W of +12 V power DC.

Estimate Source:

Sola power supply 83-12-310-3(-2) which is Newark part number 05f1134

Basis of Estimate:

Newark catalog.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.2.2.3

WBS Element Name:

Power Cable

WBS Element Definition:

This is the cable that carries power from the power supply to the front ends. It should be a shielded pair capable of carrying 0.5 A.

Ground Rules & Assumptions:

We need one power cable for each Front-end

Estimate Source:

This is Newark Model 03F2960 shielded pair.

Basis of Estimate:

Newark Catalog.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.2.2.4

WBS Element Name:

Plugs and connectors

WBS Element Definition:

These are solderless connectors for terminal strips, terminal strips and banana jacks and plugs for the power cable hook up. Don't have to be very fancy. Also the AC line for the DC supply.

Ground Rules & Assumptions:

We need some connectors for each front-end board to hook up the 12 V power and a power cord to hook up the DC supply to AC.

Estimate Source:

Survey of likely items from the Newark.

Basis of Estimate:

Newark Catalog.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.3

WBS Element Name:

Cooling

WBS Element Definition:

Since the power consumption on each front end board is rather small, all we need is a way to keep the air moving around. One blower will be mounted to blow into each octant or group of 13 front end boards.

Ground Rules & Assumptions:

We need some small cooling. One blower fan or cooling unit is required for each group of 13 front end boards.

Estimate Source:

Catalog items and labor experience. Usually this is pretty labor-light.

Basis of Estimate:

Catalogs, experience.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.3.1

WBS Element Name:

Prototype Cooling System

WBS Element Definition:

We'll need something to play around with to make sure we have adequate cooling.

Ground Rules & Assumptions:

We'll need some cooling. Enough to dissipate heat from an octant of working electronics.

Estimate Source:

Catalog items and experience with other cooling systems.

Basis of Estimate:

Newark catalog.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.3.1.1

WBS Element Name:

Cooling fan

WBS Element Definition:

This is actually a blower and it is primarily there to move hot air away rather than as direct cooling for a 13 plank octant.

Ground Rules & Assumptions:

We'll need a couple of these to prototype with.

Estimate Source:

Newark part 81F8111

Basis of Estimate:

Newark catalog.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.3.1.2

WBS Element Name:

Power Cord

WBS Element Definition:

This is the cable that AC power to the fan.

Ground Rules & Assumptions:

We need one power cable for each cooling fan.

Estimate Source:

Newark part 84N1510.

Basis of Estimate:

Newark Catalog.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.3.2

WBS Element Name:

Production Cooling System

WBS Element Definition:

This is the cost estimate for cooling the entire muon detector with the prototype cooling system.

Ground Rules & Assumptions:

We need one blower/cooling unit for each group of 13 front-end boards.

Estimate Source:

Catalog items and experience with other cooling systems.

Basis of Estimate:

Newark catalog.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.3.2.1

WBS Element Name:

Cooling fan

WBS Element Definition:

This is actually a blower and it is primarily there to move hot air away rather than as direct cooling for a 13 plank octant.

Ground Rules & Assumptions:

We need one blower for each group of 13 front-end boards.

Estimate Source:

Newark part 81F8111

Basis of Estimate:

Newark catalog.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.3.3.2.2

WBS Element Name:

Power Cord

WBS Element Definition:

This is the cable that AC power to the fan.

Ground Rules & Assumptions:

We need one power cable for each cooling fan.

Estimate Source:

Newark part 84N1510.

Basis of Estimate:

Newark Catalog.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.4

WBS Element Name:

Mechanical and Other Systems

WBS Element Definition:

Mechanical support for detector stations and gas system. In this section we describe 2 additional system needed for the muon detector. The quadrants will need to be supported to make a whole station. This support must be flexible enough to allow the insertion and removal of whole quads from a station. We will need to supply gas to each station as well. There is a provision for a gas delivery system to provide mixed gas to each arm/station/quadrant/octant/plank with all the ancillary parts.

Ground Rules & Assumptions:

We will need enough hardware to support 6 stations of muon detector with some provision for spares. We will need to supply mixed gas to each 32-channel plank with some provision for spares.

Estimate Source:

Most of the support element estimates come from the Vanderbilt mschine shop. Most of the gas items are based on our summer 1999 test beam experience and experience with a previous mixed gas delivery system.

Basis of Estimate:

Quotes and experience.

Basis of Estimate:

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.4.1

WBS Element Name:

Detector Station Mechanical Supports

WBS Element Definition:

Mechanical support system for detector stations. Stations consist of four quads. They will be supported via threaded rod from above. Threaded rods will hang from u-channels that are attached to the top of the toroid iron From below the stations will roll on wheels. The stations will be installed a quad at a time. The top and bottom of each half of a station will be connected together before rolling into the beam. These two halves must be carefully joined and this will be accomplished using Acme rods and must be held in a stable geometry after installation.

Ground Rules & Assumptions:

Illinois, Puerto Rico, and Vanderbilt will be responsible for this item. Each station needs its own support system.

Estimate Source:

Estimates are from Vanderbilt Machine Shop.

Basis of Estimate:

Estimates are from Vanderbilt Machine Shop.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.4.2

WBS Element Name:

Gas System

WBS Element Definition:

We will need an infrastructure to mix and deliver gas to our system.

Ground Rules & Assumptions:

One mixing system is sufficient for the entire detector.

Estimate Source:

See subitems below.

Basis of Estimate:

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.4.2.1

WBS Element Name:

Gas Mixing System.

WBS Element Definition:

We will buy individual gases and mix them ourselves. We anticipate using a mixture of 3 gases, but are building in the possibility of a four component gas. This system will consist of 4 MKS programmable gas flow controllers (controlled by an MKS readout module). We will also need various valves, regulators, filters, etc.

Ground Rules & Assumptions:

Illinois, Puerto Rico, Vanderbilt will be responsible for this item. We need one mixing system but will buy MKS flow controllers and a readout module for a second so that we will have spares of these items. Flow controllers tend to be specialized for each gas and flow rate so it is likely that we will need four Spare flow controllers.

Estimate Source:

Based on cost of E831 gas mixing system.

Basis of Estimate:

Based on cost of E831 gas mixing system.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.4.2.2

WBS Element Name:

Gas Distribution System

WBS Element Definition:

We will need a distribution system to get gas from the mixing system to the detector. This includes all tubing, flow meters, manifolds, etc., and the labor to assemble the system.

Ground Rules & Assumptions:

Illinois, Puerto Rico, and Vanderbilt will be responsible for this item. We need to deliver gas to both arms of the detector.

Estimate Source:

Experience with E831 system.

Basis of Estimate:

Experience with E831 system.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.4.2.3

WBS Element Name:

Gas Monitoring System

WBS Element Definition:

Monitor gas quality. We will put a plank at the outlet of the gas mixing system with a source and constantly measure gain.

Ground Rules & Assumptions:

Illinois, Puerto Rico, and Vanderbilt will be responsible for this item. We will use one of the final prototype planks, but will need some extra electronics and monitoring software.

Estimate Source:

1999 Summer beam test experience.

Basis of Estimate:

Experience in 1999 summer beam test.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.5

WBS Element Name:

Test Beam Studies

WBS Element Definition:

We plan to perform a variety of beam tests.

Ground Rules & Assumptions:

We will perform cosmic ray and beam test using planks as early as possible, then assemble a full quad and check it for operational performance. We will also perform a high rate test of a plank.

Estimate Source:

See subitems below.

Basis of Estimate:

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.5.1

WBS Element Name:

Plank Tests (Summer 2000)

WBS Element Definition:

Cosmic ray tests in the summer of 2000 primarily to test performance of new front-end electronics design and modifications to plank design for noise suppression.

Ground Rules & Assumptions:

Vanderbilt responsibility. We already have a cosmic ray test stand, but we will need to buy gas and will have labor costs associated with analysis of data, running the test, etc.

Estimate Source:

Experience with summer 1999 plank tests.

Basis of Estimate:

Experience with summer 1999 plank tests.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.5.2

WBS Element Name:

Plank Beam Test

WBS Element Definition:

Beam test to perform final test of new electronics and plank design. We will also select the gas mixture.

Ground Rules & Assumptions:

Illinois, Puerto Rico, and Vanderbilt will be responsible. We would like to run for about a month. Planks used are costed above but we will need gas, travel, housing, test stand, readout electronics, and other miscellaneous items.

Estimate Source:

Experience from 1999 Summer Test Beam run.

Basis of Estimate:

Experience from 1999 Summer Test Beam run.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.5.3

WBS Element Name:

Quadrant Test

WBS Element Definition:

Operational test of a quadrant. May be done in a cosmic ray test stand or preferably in a test beam of some sort.

Ground Rules & Assumptions:

Illinois, Puerto Rico, and Vanderbilt will be responsible. We would like to run for about a month. Planks used are costed above but we will need gas, travel, housing, test stand, readout electronics, and other miscellaneous items.

Estimate Source:

Experience from 1999 Summer Test Beam run.

Basis of Estimate:

Experience from 1999 Summer Test Beam run.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.5.4

WBS Element Name:

High Rate Studies

WBS Element Definition:

We plan to test our plank design for rate problems. We would like to perform a test similar to the one that D0 performed when they put a detector element near the Tevatron beam for an extended period. We would prefer to perform this test in the C0 hall, and use an operational plank or planks that we would monitor over time. This test could start within a year.

Ground Rules & Assumptions:

Illinois, Puerto Rico, and Vanderbilt will be responsible for this item. Planks used are costed above but we will need gas, travel, housing, test stand, readout electronics, and other miscellaneous items.

Estimate Source:

Experience from 1999 Summer Test Beam run.

Basis of Estimate:

Experience from 1999 Summer Test Beam run.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.6

WBS Element Name:

Hardware and Software Specific to Muon Development

WBS Element Definition:

In this element the hardware and software necessary to the development, prototype and testing of the Muon system is described.

Ground Rules & Assumptions:

An joint effort of the hardware and software groups at Computing Division will design the test stands for the Muon system.

Cost Estimate Source:

Fermilab Computing Division.

Basis of Cost Estimate:

Engineering judgment and PO from vendors.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.6.1

WBS Element Name:

Hardware

WBS Element Definition:

This element describes the hardware to interface Muon front-end circuitry to the BTeV test stands.

Ground Rules & Assumptions:

The hardware consists of boards with simple programmable logic.

Cost Estimate Source:

PCB board vendors, miscellaneous electronic components vendors.

Basis of Cost Estimate:

Similar board designs for other subsystems.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.6.1.1

WBS Element Name:

Hardware, Muon Specific test adapters

WBS Element Definition:

This element describes the board and probe cards (if necessary) to test Muon front-end circuitry.

Ground Rules & Assumptions:

This hardware is designed to allow the characterization of the Muon ASDQ boards.

Cost Estimate Source:

PCB board vendors, miscellaneous electronic components vendors.

Basis of Cost Estimate:

Previous experience of Fermilab engineers procuring this type of interface boards.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.6.2

WBS Element Name:

Software

WBS Element Definition:

This element includes all software efforts that will be needed for the development of on-line code for the test-stands (data-acquisition and monitoring), and databases for the various components that will be tested.

Ground Rules & Assumptions:

Test stands will be developed at various sites using a common PC based platform and code development will be shared amongst all the institutes. Databases are necessary for book-keeping of the components, tests and results that will be performed on all the components, sub-assemblies, modules and stations. Computing professionals will be required to write substantial part of this code.

Cost Estimate Source:

Estimated number of days required for computer professionals to code this software and estimated cost of several software packages.

Basis of Cost Estimate:

Previous experiences with similar projects.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.6.2.1

WBS Element Name:

Monitoring Software

WBS Element Definition:

This element includes all higher level software for the Muon test stands.

Ground Rules & Assumptions:

Database and user-interface software.

Cost Estimate Source:

Estimated number of days required for computer professionals to code this software and estimated cost of several software packages.

Basis of Cost Estimate:

Previous experiences with similar projects.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.6.2.2

WBS Element Name:

FEB & DCB Testing Software

WBS Element Definition:

This element includes all software specific to the testing of Muon front-end and Data Combiner boards.

Ground Rules & Assumptions:

Muon specific test software to interface to the more general higher level test stand software.

Cost Estimate Source:

Estimated number of days required for computer professionals to code this software and estimated cost of several software packages.

Basis of Cost Estimate:

Previous experiences with similar projects.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.7

WBS Element Name:

ES&H

WBS Element Definition:

This WBS element covers the ES&H costs of all components associated with the Muon Detector.

Periodic safety reviews and training are included, as well as overall safety issues such as gas systems, signal cabling, power supplies and power cabling, front end electronics, cooling, environmental safety and radiation safety.

Ground Rules & Assumptions:

The Muon Detector designer will consider ES&H issues starting from the conceptual stage of project. This should help to bring the overall cost of the project down by avoiding expensive redesigns and retrofits.

All applicable BTeV Standards and Methodology guidance apply.
All applicable ES&H guidance applies, which includes Fermilab mandatory periodic safety training on Radiation, Hazardous Materials, Gas systems, High Voltage, Low Voltage, Machine Shop safety, etc. as applicable.

Cost Estimate Source:

This is a summary item.

Basis of Cost Estimate:

The estimate is based on past experiences with projects of similar size and complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.7.1

WBS Element Name:

Sensors, Mechanical, Gas and Cryogenics

WBS Element Definition:

This WBS element covers the costs associated with ES&H issues relating to the non-electronic Muon detector components. . Including the detector arrays, gas systems, mechanical supports, and their associated controls, monitors, interlocks and alarms. Also environmental safety and radiation safety issues.

Also includes periodic safety reviews, applicable safety and hazard awareness training.

Ground Rules & Assumptions:

All applicable BTeV Standards and Methodology guidance apply.

All applicable ES&H guidance applies, which includes Fermilab mandatory periodic safety training on Radiation, Hazardous Materials, Gas systems, High Voltage, Low Voltage, Machine Shop safety, etc. as applicable.

Cost Estimate Source:

Historical vendor quotes for detectors of similar complexity.

Contributions from Fermilab Computing Division Electronic Systems Engineering Department personnel.

Basis of Cost Estimate:

The estimate is based on past experiences with projects of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.7.2

WBS Element Name:

Electrical and Electronics

WBS Element Definition:

This WBS element covers the costs associated with ES&H issues relating to the electrical components associated with the Muon Detector.

Includes front-end electronics, cooling, signal connectors and cabling, power supplies, power connections and cabling, and their associated monitors, interlocks, and alarms. Also environmental safety and radiation safety issues.

Also includes periodic safety reviews, applicable safety and hazard awareness training.

Ground Rules & Assumptions:

All applicable BTeV Standards and Methodology guidance apply.

All applicable ES&H guidance applies, which includes Fermilab mandatory periodic safety training on Radiation, Hazardous Materials, Gas systems, High Voltage, Low Voltage, Machine Shop safety, etc. as applicable.

Cost Estimate Source:

This is a summary item.

Basis of Cost Estimate:

The estimate is based on past experiences with projects of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.7.2.1

WBS Element Name:

High Voltage Power

WBS Element Definition:

This WBS element covers the ES&H costs associated with safety issues relating to the Muon Detector High Voltage system.

Including safety issues associated with the Muon Detector HV source, HV distribution, and HV monitor and interlock system.

Ground Rules & Assumptions:

All applicable BTeV Standards and Methodology guidance apply.

All applicable ES&H guidance applies, which includes applicable Fermilab mandatory periodic safety training on High Voltage safety issues.

Cost Estimate Source:

Historical vendor quotes for detectors of similar complexity. Current vendor quotes.

Contributions from Fermilab Computing Division Electronic Systems Engineering Department personnel.

Basis of Cost Estimate:

The estimate is based on past experiences with projects of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.7.2.2

WBS Element Name:

Low Voltage Power

WBS Element Definition:

This WBS element covers the ES&H costs associated with safety issues relating to the Muon Detector Low Voltage (but potentially high current) system.

Including safety issues associated with the Muon Detector Low Voltage power supplies, control, distribution, monitor and interlock systems.

Ground Rules & Assumptions:

All applicable BTeV Standards and Methodology guidance apply.

All applicable ES&H guidance applies, which includes Fermilab mandatory periodic safety training on Radiation, Hazardous Materials, Gas systems, High Voltage, Low Voltage, Machine Shop safety, etc. as applicable.

Cost Estimate Source:

Contributions from Fermilab Computing Division Electronic Systems Engineering Department personnel.

Basis of Cost Estimate:

The estimate is based on past experiences with projects of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.7.2.3

WBS Element Name:

Front-end Electronics

WBS Element Definition:

This WBS element covers the costs associated with ES&H issues relating to the on-detector electronics associated with the Muon Detector.

Includes cooling, signal connectors and cabling, power supplies, power connections and cabling, and their associated monitors, interlocks, and alarm systems.

Also includes periodic safety reviews, applicable safety and hazard awareness training.

Ground Rules & Assumptions:

All applicable BTeV Standards and Methodology guidance apply.

All applicable ES&H guidance applies, which includes Fermilab mandatory periodic safety training on Radiation, Hazardous Materials, Gas systems, High Voltage, Low Voltage, Machine Shop safety, etc. as applicable.

Cost Estimate Source:

Contributions from Fermilab Computing Division Electronic Systems Engineering Department personnel.

Basis of Cost Estimate:

The estimate is based on past experiences with projects of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.7.3

WBS Element Name:

Environmental

WBS Element Definition:

This WBS element covers the costs associated with ES&H issues relating to the Muon Detector environmental systems, including temperature and humidity monitoring and alarm systems. Also relevant radiation safety issues.

Also includes periodic safety reviews, applicable safety and hazard awareness training.

Ground Rules & Assumptions:

All applicable BTeV Standards and Methodology guidance apply.

All applicable ES&H guidance applies, which includes Fermilab mandatory periodic safety training on Radiation, Hazardous Materials, Gas systems, High Voltage, Low Voltage, Machine Shop safety, etc. as applicable.

Cost Estimate Source:

Historical vendor quotes for detectors of similar complexity.

Contributions from Fermilab Computing Division Electronic Systems Engineering Department personnel.

Basis of Cost Estimate:

The estimate is based on past experiences with projects of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.7.4

WBS Element Name:

Radiation Safety

WBS Element Definition:

This element covers the costs of any Muon Detector radiation safety issues, including Radiation Safety training and controlled access to the beam area.

Periodic safety reviews, applicable safety and hazard awareness training are included.

Ground Rules & Assumptions:

All applicable BTeV Standards and Methodology guidance apply.

All applicable ES&H guidance applies, which includes Fermilab mandatory periodic safety training on Radiation, Hazardous Materials, Gas systems, High Voltage, Low Voltage, Machine Shop safety, etc. as applicable.

Cost Estimate Source:

Historical vendor quotes for detectors of similar complexity.

Contributions from Fermilab Computing Division Electronic Systems Engineering Department personnel.

Basis of Cost Estimate:

The estimate is based on past experiences with projects of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.7.5

WBS Element Name:

Training

WBS Element Definition:

This WBS element covers the costs associated with ES&H issues relating to training pertinent to the Muon detector.

Also includes periodic safety reviews, applicable safety and hazard awareness training.

Ground Rules & Assumptions:

All applicable BTeV Standards and Methodology guidance apply.

All applicable ES&H guidance applies, which includes Fermilab mandatory periodic safety training on Radiation, Hazardous Materials, Gas systems, High Voltage, Low Voltage, Machine Shop safety, etc. as applicable.

Cost Estimate Source:

Historical vendor quotes for detectors of similar complexity.

Contributions from Fermilab Computing Division Electronic Systems Engineering Department personnel.

Basis of Cost Estimate:

The estimate is based on past experiences with projects of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.8

WBS Element Name:

Transportation to and Installation and Testing at C0

WBS Element Definition:

This WBS element covers

a) the costs associated with transporting the Muon Detector components to C0,
b) the costs associated with assembly and installation of Muon Detector components, including rigging and surveying. Also the fixtures and rail system for the installation and required cables, cooling pipe routes, and support structures., and
c) the costs associated with pre-beam Muon Detector system testing.

Ground Rules & Assumptions:

All applicable BTeV Standards and Methodology guidance apply.

All applicable ES&H guidance applies, which includes Fermilab mandatory periodic safety training on Radiation, Hazardous Materials, Gas systems, High Voltage, Low Voltage, Machine Shop safety, etc. as applicable.

Cost Estimate Source:

The previous experiences of physicists and engineers with detectors of similar complexity.

Contributions from Fermilab Computing Division Electronic Systems Engineering Department personnel.

Basis of Cost Estimate:

Previous experience doing similar work with detectors of similar complexity.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.8.1

WBS Element Name:

Transportation

WBS Element Definition:

Each institution (Illinois, Puerto Rico, and Vanderbilt) will ship the quads that they have assembled to Fermilab.

Ground Rules & Assumptions:

We are assuming this will involve the use of an air-conditioned semi-trailer and or container ship (from Puerto Rico). This cost also includes any special packaging that is necessary.

Estimate Source:

Based on past shipping of two previous detectors.

Basis of Estimate:

Based on past shipping of two previous detectors.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.8.2

WBS Element Name:

Installation at C0

WBS Element Definition:

Installation of quads in the C0 hall. This includes rigging, labor.

Ground Rules & Assumptions:

Vanderbilt, Illinois, Puerto Rico will be responsible.

Estimate Source:

Installation of previous detectors at Fermilab.

Basis of Estimate:

Installation of previous detectors at Fermilab.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.8.3

WBS Element Name:

Survey

WBS Element Definition:

Survey of detectors once in position.

Ground Rules & Assumptions:

We need to know the z positions of the detector stations to within a mm, and check for yaw and pitch.

Estimate Source:

Based on previous experience surveying detectors at Fermilab.

Basis of Estimate:

Based on previous experience surveying detectors at Fermilab.

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.8.4

WBS Element Name:

Test Muon System

WBS Element Definition:

Operational performance test and shakedown of installed muon system.

Ground Rules & Assumptions:

Responsibility of Illinois, Puerto Rico, and Vanderbilt. We assume this will take 45 days.

Estimate Source:

Previous experience bringing up detector systems at Fermilab.

Basis of Estimate:

Previous experience bringing up detector systems at Fermilab

BTeV WBS Dictionary
Basis of Cost Estimate

WBS Element Number:

1.5.9

WBS Element Name:

Muon Detector Project Management

WBS Element Definition:

This element consists of the costs associated with all management activities related to the Muon detector.

Ground Rules & Assumptions:

This element includes coordination of the work carried out at various institutes, site-visit, vendor visit, book-keeping, accounting, and reporting to internal and external reviews of the project. Review at regular intervals is necessary to keep track of the progress of the project. Travel to various sites are needed to coordinate the smooth running of the project and the timely delivery of components needed from the vendors. A project engineer will monitor the progress and coordinate with the project management in 1.20 as required.

Cost Estimate Source:

The cost is basically an estimate of the number of travels that is deemed to be necessary. It also includes the time that it will take the engineers and technicians to prepare and attend the reviews. Labor is costed at Fermilab rates. All trips are based on experience and costed based on place and length of travel.

Basis of Cost Estimate:

Estimate is based on experiences with projects of similar complexity.